Acoustics BULLETIN

VOL 28 No5 Sept/Oct 2003

Pioneers of Acoustics: Alan Blumlein

Assessing and controlling occupational vibration exposure

Uncertainty of vibration exposure evaluation

Young people's attitude to noise-induced hearing loss

Institute of Acoustics

Acoustics BULLETIN

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Institute of Acoustics

The Institute of Acoustics was formed in 1974 through the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society and is the premier organisation in the United Kingdom concerned with acoustics. The present membership is in excess of two thousand and since 1977 it has been a fully professional Institute. The Institute has representation in many major research, educational, planning and industrial establishments covering all aspects of acoustics including aerodynamic noise, environmental, industrial and architectural acoustics, audiology, building acoustics, hearing, electroacoustics, infrasonics, ultrasonics, noise, physical acoustics, speech, transportation noise, underwater acoustics and vibration. The Institute is a Registered Charity no 267026.

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Brüel & Kjær

Dear Members

I was pleased to introduce Nick Antonio to the last Council meeting following his election at the recent AGM. Along with him was Adam Lawrence as the co-opted younger members' representative. To ensure that all areas of the Institute's activities are properly represented Professor Tim Leighton has also been co-opted for a further year. Council and its committees have much to do in the coming year and I am looking for members who are willing to serve on committees to help further our interests. It is also not too early to remind members that there will be vacancies for nominations to Council in 2004. The AGM will be held at the Spring Conference, planned to take place at Southampton University in late March.

Some matters of interest to members are brought to Council on a regular basis. One of these is representation on British and International standards committees and the dissemination of relevant information to members. This is an important area and one in which the Institute should play a significant role. Many of you are very active on a number of committees but we have never been able to co-ordinate our representation very well. Nick Antonio has been given the task of bringing together the various strands so that Council can determine how best we can improve this service to members. If you have any suggestions or comments please let me know.

I am always pleased to hear from employers, which I do on a regular basis, about how highly they regard the quality of work carried out by our members. It is important that the acoustics profession is seen to be setting the highest of standards and I ask all of you to encourage your colleagues to consider joining the Institute, if they have not already done so. One of the benefits the Institute provides via the various approved education centres is the Certificate of Competence programme. There are several courses running this year and if you want to take advantage yourself, or persuade a colleague to attend, see the web site for details.

There are two cracking conferences, 'Sound-bite' and 'Reproduced Sound 19', lined up in the autumn at our new venue in Oxford. See you there!

Yours sincerely

Geoff Kerry
President

Spring Conference

IPPC, PA(N)D, NCE and NVH

The inaugural meeting of the Noise and Vibration Engineering Group
Village Hotel, Coventry, 15 and 16 May 2003

This year it was the turn of the Noise and Vibration Engineering Group (formerly the Industrial Noise Group) to organise the Spring Conference. Two main themes were chosen: *Implications of New Legislation*, and *Engineering Noise Control/Noise Prediction*. The Rayleigh Medal was also presented at the conference to Prof Dr Hugo Fastl in recognition of his contribution to the field of Psychoacoustics (reported in *Acoustics Bulletin* Vol.28 no4).

Implications of Integrated Pollution Prevention and Control (IPPC)

Chairman: **Nick Antonio**

Lesley Omerod (Environment Agency) opened the morning session with a presentation on the Environment Agency role in IPPC. She described the background behind the IPPC, its proposed workings and gave a frank assessment of some of the possible shortcomings. She went on to outline how these were being addressed, perhaps the most notable actions being the 'working together protocol' intended to improve communication between local authorities and the EA.

Bernard Postlethwaite (Bureau Veritas Acoustic Technology) provided the consultant's view of the application of IPPC. Bernard illustrated some practical aspects of noise control by going through a number of case histories covering a variety of large-scale industrial processes in a gas process plant. He pointed out the lack of advice in the European BREF documents and expressed the hope that this might be remedied in future.

Stepping in at late notice, **Peter Sacre** (AEC) discussed IPPC from a manufacturer's experience. Basing his talk on Airbus experience and information from Claire Williams of Airbus, Peter raised a number of interesting questions which must be resolved. It is clear that if IPPC is to settle into a successful noise control regime certain clarifications must be made. These include extent of site boundaries and integration of IPPC premises into existing industrial areas.

Gordon Brown presented a joint paper on the EHO's view (the other author being **Clive Pink** of Suffolk Coastal DC). Gordon clearly identified a number of issues with the IPPC system. These included potential under-resourcing in noise expertise in the EA and a possible significant underestimate in the time taken to assess applications. Gordon examined the concept of BAT (best available technology) and compared this with CATNIP (cheapest available technology not involving prosecution), and looked at the difficulty in identifying the difference. Gordon highlighted the fact that IPPC effectively removes the ability of a local authority to take nuisance action over IPPC premises, and like previous speakers emphasised the importance of liaison between the EA and LA.

Different aspects of noise exposure

Chairman: **David Bull**

The second session opened with a presentation by **Tim Ward** (HSE) on the implications of the Physical Agents (Noise) Directive for workplace noise regulations. He set out the changes that arise from the Directive, notably a lowering of the action levels, and new limit values.

He also discussed the opportunity to change the emphasis of the Regulations so that noise exposure assessment will be set more positively in the context of risk assessment, putting the onus firmly on the employer to manage the risk. It is likely that the term 'competent person' will not appear in the new UK Regulations (due February 2006), but the accompanying guidance document will outline the skills and knowledge necessary to carry out the risk management process. Hence, there will remain an important role for competent people and services in providing a full range of good quality technical advice including the measurement and assessment of noise exposure.

A consultative document will be issued in the first quarter of 2004, with a consultation period of approximately four months.

'Implications of the Physical Agents (Noise) Directive for health surveillance for noise induced hearing loss in the UK' was given by **Clare Bowling** (HSE). She reviewed the current position and then went on to discuss the much wider implications arising from the new Directive. Issues such as when to conduct the surveillance, who it will apply to (many more workers under the new regulations), who will conduct the testing, and what employers need to do. The HSE will be issuing new guidance, particularly on audiometry. There will be a full consultative process including a meeting later this year with expert industrial representatives.

'An industry perspective of health surveillance in relation to the Noise at Work Regulations' was given by **Lee Knowles** (Rank Hovis McDougall). After giving an outline introduction to the group, he set out their Hearing Conservation Policy, in particular a single action level of 85dB(A). Management responsibilities were clearly identified to reduce noise exposure, and health surveillance was part of a routine process. This included counselling for all affected employees and further investigation if appropriate. The approach was considered to be successful: out of

Village Hotel, Coventry. Venue for the 2003 Spring Conference

18 papers were presented at the 2003 Spring Conference

some 2000 employees exposed to noise on 35 sites, only one compensation claim was received last year.
'Noise exposure of call centre operators' was presented by **Keith Broughton** (HSE). He outlined the possible size of the problem, in that some 400,000 people are now employed in such work, and to be able to study the implications more fully, a special dose meter is being developed. Various studies have found that with normal working conditions, in particular where background noise is not excessive, exposure is not likely to exceed the provisions of the Noise at Work Regulations. However, the new Directive would bring further implications especially relating to acoustic shock (very short duration high frequency impulses). These can be distressing: research in Australia and Italy has shown up some of the implications, especially the need for stress management strategies.
Murray Hodgson (University of British Columbia, Vancouver) presented his first paper of the conference: a whole series of measurement investigations at various industrial premises where the low frequency energy content (below 500Hz) was significant. Entitled *'Contribution of low frequency industrial noise to worker noise exposure'*, the aim was to identify potential applications for active noise control to reduce worker exposure. He showed that the low frequency energy content can vary from 3% to 76%, so that in some industries it is very significant. This led him to choose two sites for the future application of active control techniques.
In *'Some limitations in the use of hearing protection'*, **Geoff Kerry** (Salford University) presented research data showing that very high levels of peak sound could be induced inside a muff by various mechanical contacts with the muff which invariably happen in practical working situations. These varied from tapping with a pen, banging on scaffold, or jumping from a chair, to releasing from the head. Peak levels in excess of the Peak Action Level could easily be generated although he had reservations about the limitations of the miniature microphones used. He made the point that he was still looking for more accurate microphones to carry out more definitive research.
'Noise exposure in military bands', by **Hilary Notley** and **Gillian Williams** brought a very lively end to the day's proceedings with loud military band music replayed at a typical exposure level for a musician. They discussed exposures measured with typical playing routines and showed that consistent exposures exceeded the First Action Level, and in many cases also the Second Action Level. Various control techniques were investigated, but source and receiver control were soon ruled out as totally unacceptable! Initial experimental screens were not very effective. However further investigations will be made with redesigned screens and with new designs of custom-made ear plugs with appropriate filters.
Thursday evening was taken up with the Institute of Acoustics AGM, including a presentation and explanation of the Annual Accounts by the Hon. Treasurer, Keith Broughton. A sherry reception and the

continued on page 6

The President entertains the guests of honour, Prof Dr-Ing Hugo Fastl and Frau Fastl

Spring Conference 2003

continued from page 5

Conference Dinner followed, after which Honorary Fellowships of the IOA were presented to Phil Doak and Chris Rice.

Rayleigh Medal presented

The first presentation on the Friday morning was that of the *Rayleigh Medal* to **Prof Dr-Ing Hugo Fastl**, who then gave the *2003 Rayleigh Medal Lecture*. This was a fascinating insight into sound quality and how it affects our perception of quality in a more general sense. The lecture included several audible examples, delivered and explained with characteristic clarity and wit by the *Rayleigh Medallist*. We would have loved to hear him play the double bass too!

Engineering noise control

Chairman: **Tim Ward**

Stephen Walsh (University of Loughborough) opened the next technical session with a paper on *'Wavelet analysis of vehicle door closure sounds'*. The sound quality of a vehicle is composed of many kinds of noise, including speed-related, engine-related and transient phenomena (eg. door closure sounds). Stephen described the use of wavelet analysis to look at the transient signals. Because wavelet analysis is able to make use of varying frequency resolution over time, it has advantages in looking at transient signals: it is more efficient and reveals more details. Door closure events can be analysed in a single step, and provides a better means of representing the subjective sound quality of these events.

The subject of Liverpool University's **Andy Moorhouse** was *'Virtual acoustic prototypes as a tool for low noise design'*. Virtual prototyping is a technique which can be used to assess the likely noise and sound quality characteristics of a design without the need for physical modelling or prototyping. Andy described the methods with reference to specific examples from a recently completed EU-sponsored project. Good agreement was found between the directly measured and the VAP-predicted sound power, indicating that the VAP technique has the potential to be a useful design tool for noise control and conformity verification at the design stage.

Prof Dr-Ing Hugo Fastl receives the Rayleigh Medal and Certificate from the President, before delivering the 2003 Rayleigh Medal Lecture

Murray Hodgson (University of British Columbia, Vancouver) presented some results from his department's work on the active control of non-diffuse noise in workrooms. Murray noted that active noise control (ANC) is a hot topic in acoustics, but that it is not often applied to rooms. He then ran through the major considerations needed to apply ANC to rooms, which include whether the sound field is diffuse or non-diffuse, whether control is required on a global or local level, and, importantly, how to optimise the control source and error sensor positions. Finally, he described a new design method for ANC in rooms (the image-GA method) which has been shown to be effective both in numerical and experimental investigations.

Noise prediction

Chairman: **Dave Lewis**

The final session of the conference on Noise Prediction was opened by **Steven Dance** (South Bank University) who presented a paper on: *'Accurately representing the sound field in industrial halls using the ray tracing technique'*. He introduced the principles and assumptions inherent in the ray tracing technique and described how accuracy is dependent upon how the room geometry and scattering objects within the space are defined. Recent developments in hybrid image source/ray tracing models and cone/pyramid tracing methods were also described. He concluded by discussing the application of these techniques in industrial halls to quantify the potential benefit of alternative noise control strategies and the potential extension to model external environmental noise.

Murray Hodgson (University of British Columbia, Vancouver) highlighted the need for simple accurate prediction tools to assist in workroom design and the identification of noise control requirements. In his paper, *'Plant noise - an empirical method for modelling factory noise'*, he described the basis from which the algorithms in the prediction tool were derived and the features of the software package produced. These features include visualisation and auralisation of the sound field derived from multiple source within a workroom. He went on to describe the validation of the empirical model against ray tracing and current work being undertaken to validate the models in real workrooms. He concluded that the design objectives had been met and that in typical workrooms the method was fast and reasonably accurate.

Peter Sacre perplexes Dennis Baylis (left), advertising manager, *Acoustics Bulletin*

Martin Hassett (M W Kellogg) stepped in at the last minute for Jon Richards to present a brief paper, *'Validation of ISO 9613 and Joint Nordic Methods of propagation calculation'*. The noise levels measured at distances up to 1600m from a large test source were compared with predicted levels using three prediction methods. Differences of the order of ±4dB were found and possible reasons for the differences were discussed.

The final paper, *'Approximate method for determining the optimal position for noise sources near rectangular apertures'* was presented by **Jane Horner** (University of Loughborough). She described the parameters that need to be considered and presented the background to a qualitative method for assessing field locations for sources. The aim of the work was to investigate whether a more fundamental understanding of the transmission of noise through apertures could lead to alternative methods for minimising noise break-out.

David N Lewis MIOA

The exhibition was well supported by instrument manufacturers

Measurement and Instrumentation Group
Call Centres – A Measurement Headache

An acoustic teapot, a head made from plumbing bits, and a clockwork noise limiter were included in the presentations at the Measurement and Instrumentation Group's meeting on call centre noise exposure. Maybe the Liverpool Tate venue had something to do with the inspiration to take a different view and certainly the meeting benefited from the different views of fifty delegates from a diverse range of professions; call centre operators, personal injury lawyers, headset manufacturers, the MOD and acousticians.

Keith Broughton (Health and Safety Executive) presented the opening paper: *'Noise exposure levels in call centres'* (produced jointly with Jacqui Patel of the Health and Safety Laboratory). This gave an overview of the situation as he reported HSE's measurements at 15 call centres on 150 operators. He found call centre staff are unlikely to exceed the first, 85dB(A), action level of the Noise at Work Regulations 1989 and that the risk of hearing damage is minimal. He also raised the difficult problem of acoustic shock, which was to feature repeatedly through the meeting, where the headset gives out a sudden high-level sound. Operators are reporting ill effects, although there is little evidence that the exposure is sufficient to be considered a risk to hearing.

Tony Bayley (Plantronics) followed with *'Acoustic limiting in headset systems'*. He reviewed the European legislation for sound limiting in headsets and discussed the limiting techniques used in current headset systems, particularly those incorporated into the headset itself. He also considered other signal processing to enhance user comfort. He emphasised that, while headset limiting can ensure compliance with acoustic shock requirements relating to product safety, compliance with noise exposure legislation cannot be guaranteed by the choice of equipment. The noise exposure depends on the fit of the headset on the individual's ear, the nature of the work, and working pattern. Sound level monitoring and control are still required to ensure health and safety legislation is met.

Hans Gierlich (Head Acoustics) presented *'Artificial head technology – applications for headset measurements in call centres'*. This paper concentrated on two issues:

1. a reliable and reproducible technology for realistic testing of the headset receiving characteristics; and

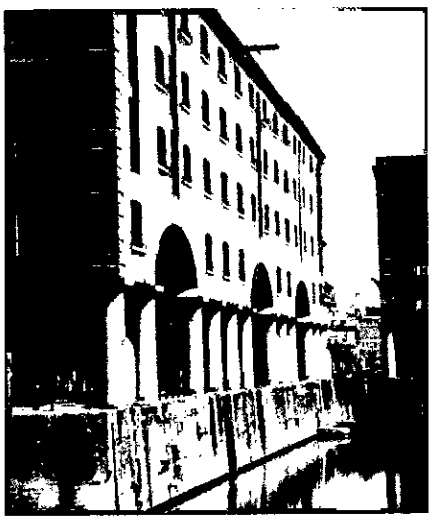
2. a methodology for realistic in situ measurement of the individual sound pressure in the listener's ear.

He concluded that headset measurements using artificial heads conforming to ITU-T recommendations P.57 and P.58 are close to the average measured on human subjects but more advanced tests are also required to determine the behaviour of a headset in combination with signal processing in the terminal and call centre. He also recommended measurements in the ear when assessing an individual's exposure because it may deviate from the average response by as much as 10dB.

Paul Darlington (Apple Dynamics Ltd) gave a lively presentation on *'Practical measurement of telecommunication receiver electro-acoustics for the computation of acoustic dose'*. The paper proved less formidable than the title! He argued for measurements on an artificial head because the Noise at Work Regulations establish limits on the equivalent unobstructed noise level outside the ear. He introduced a simple, non-standard dummy head and presented comparative measurements on this and two standard devices, the Head Acoustics measurement system and the Knowles Electronics KEMAR. He concluded the pressure response of a headset, if quoted in terms of the equivalent unobstructed pressure, could be measured with sufficient accuracy using a simple and inexpensive artificial head.

Richard Tyler (AVI Acoustic & Vibration Instruments Ltd) followed on with: *'A new non-invasive monitor to measure noise exposure from headsets'*. He described the development of an in-line signal monitor used to log noise exposure. The device converts the electrical signal to an equivalent noise level, using a frequency dependent headset-to-wearer transfer function obtained with the simple head described in the earlier paper by Paul Darlington. The device logs both one-minute L_{eq} values of the equivalent unobstructed level of the headset, and the corresponding background levels from an integral microphone. A second stage, fast sampling option, is being developed to record incoming acoustic shock events.

Acoustic shock featured repeatedly throughout the day



The meeting was held in Liverpool - pictured here is the city's Albert Dock

After lunch the meeting changed gear from measurement to practical management and control. **Mike Wagland** (BT) offered practical advice for call center operators in *'Managing acoustic risks in contact centres'*. He described how BT is combating acoustic shock events (called noise interference by BT) with management procedures. Staff are trained to be familiar with the sounds that may occur and the action to take, and there is follow-up testing of equipment associated with any reported event. Mike also reported how BT has found compatibility problems, affecting call quality, with some shock filters currently on the market. He introduced an alternative device developed by BT.

John Turnbull (BT Exact Technologies) followed up this presentation with *'Development of the defender noise limiter for use in call centres'*. He described in detail the particular requirements for a limiter and the development of BT's own device to limit noise exposure and remove acoustic shock events.

Ben Lawton (ISVR) presented *'Audiometric findings in call centre workers exposed to acoustic shock'*, showing us some of the evidence submitted in personal injury claims. Typical cases report hearing loss, tinnitus, pain or unpleasant sensations in the ear, and psychological reactions. The medical evidence showed no neurological deficit and he concluded that acoustic shock is an emotional effect requiring stress counselling and psychiatric assessment. In the face of such symptoms he suggested prevention rather than measurement is required.

Wally Mellors (Independent Consultant) reported the results of an ETSI (the telecommunications standards group) study into the existing standards and approval documents dealing with acoustic safety requirements for telecommunications terminal equipment. In his presentation, *'Call centres - ETSI work on acoustic exposure'*, he steered a clear pathway through European and American legislation and the current standards. He then moved on to some of the specific problems of call centres and how these are being addressed in the work of ETSI. He made particular mention of the needs of hearing aid users and the trauma of acoustic shock. He warned that the postulated startle trauma might be real although related to stress rather than hearing damage.

The final presentation by **Robert Beaman** (RAF Centre of Aviation Medicine), *'Communications in a military environment - a review of some practical problems'*, opened our eyes to the problem of communications in extremely high levels of noise. He cited the situation of ground operations by aircraft where sound levels are in excess of 140dB(A). In such environments the background noise presents problems for speech transmission. He considered the benefits of throat, bone conduction, and noise cancelling microphones and we were able to listen to the quality of the speech that came through in some high noise conditions. And where did the teapot, the plumbing bit head and the clockwork limiter come in? You'll have to ask someone who was there. And if you weren't, then you missed a truly excellent meeting.

Liz Brueck MIOA

Editor's Notes

Ian F Bennett BSc CEng MIOA
Editor

Vibration is the flavour of the month. There is a great deal of interest in the Physical Agents Directive and its daughters, among acousticians active in industrial safety and all those looking for correct assessments of workplace vibration. I hope the complementary pair of articles by Chris Nelson and Paul Pitts will be helpful.

John Tyler's essay on Alan Blumlein continues the *Pioneers of Acoustics* series in this issue, and for those (like me) who were wondering 'Alan who?' it is a fascinating account of a latter-day polymath. Blumlein thought of, and experimented with, stereo sound reproduction seventy years ago, but is little known nowadays because of his untimely death in a wartime air crash. Perhaps the other reason for his relative obscurity is the amount of classified research he carried out up to and during the war, meaning that many of his accomplishments have been shrouded in secrecy for too long. Who knows what he might have achieved had he survived hostilities?

Could I ask all our loyal readers for suggestions for further *Pioneers*? I am sure there are still some scientists and engineers who warrant the *Acoustics Bulletin* treatment, but history has never been my forte - well, I do know some music history, but calling Franz Joseph Haydn an acoustician is stretching credibility a bit far.

Finally, I record my thanks to John Miller for his service at the helm of the Bulletin Board of Management throughout my occupation of the Editor's chair. Many of the changes you have seen in the Bulletin, and some of those as yet invisible, would not have come about without John's enthusiasm, commitment to the cause, and dry humour.

Copy date for November/December is 10 October. Keep the material for publication flowing in!

Ian Bennett

NW Branch Report

Braking quietly in Derbyshire

Approximately 12 people attended the North West Branch visit to Federal Mogul Friction Products. Initially we assembled in a meeting room for refreshments. Our host and speaker was Dr Tristan Hargreaves, the group's NVH Engineer. Tristan gave us a background to the Federal Mogul empire, which operates in many countries across the world and has an interest in the engineering, manufacture and testing of brake linings for cars, commercial vehicles and railway vehicles, one of its famous brand names being Ferodo brake products.

Tristan explained the general principles of braking - which put simply is to convert kinetic energy into heat - and he demonstrated examples of various brake systems from cars up to rail vehicles. Increasing customer expectations means that whereas a response perfectly acceptable 15 or 20 years ago - 'That's perfectly normal sir, the brakes always squeak like that' - today is certainly not sufficient. This means that noise performance is a very important aspect of new car design and in some cases rates as important as actually stopping the car.

Noise performance is very important in new car design

This has become a very competitive business and there is a big emphasis on problem solving. Obviously car manufacturers do not come to Tristan saying they are really pleased that their brakes do *not* make a noise, but they do come saying they have a problem and it must be solved very quickly. Tristan quoted one example where the client was demanding answers even before they had sent the test samples through!

Dynamometers are used to simulate brake problems and to test brake systems in the workshop. This involves running a brake system on an axle with a pre-programmed sequence of speeds, loads and repeated braking actions. The braking action is performed under various temperatures and brake pressures to reflect different driving conditions and to attempt to replicate a particular noise problem. The noise and vibration of various elements of the brake system are monitored during the programme cycle. Tristan uses a scanning laser instrument to measure vibration without direct contact on the parts of interest.

In addition to controlled dynamometer tests, cars are driven by experienced drivers on Peak District roads to make a subjective assessment of the braking performance. Federal Mogul also uses test drives in southern Spain where conditions are dry with steep roads - the worst possible conditions for brakes, but quite a nice little number if you are the driver!

Tristan then moved on to solutions and explained how once you have discovered what is vibrating, you can stop it vibrating. This often involves increasing the mass at maximum points of vibration.

We then moved down to the works to see dynamometer tests being carried out and a demonstration of the scanning laser equipment used to analyse an incredibly loud brake squeal problem. Following this we moved outside to see several real cars that were being tested, but we were sworn to secrecy concerning their names. All that can be said is that one was a particularly nice car! We finished the visit with a trip to the laboratory where we were shown some of the analysis equipment, including a hammer test used to induce vibration in a hub. Showing remarkable intuitive predictive skills Tristan estimated that the hub would vibrate at 851Hz when hit with a hammer. He hit it, and it did, at least within a Hz or so!

The visit was completed by a trip to a very pleasant local hostelry where the technical discussion continued over a pint or two.

Paul Freeborn

D W Robinson Prize

IOA Vice President presents graduate award

Bernard Berry, Vice President of the Institute of Acoustics responsible for international affairs, presents the D W Robinson Prize to **Jane Bevan**, shortly after the recent Graduation ceremonies at the Institute of Sound and Vibration Research (ISVR).

This prize, made jointly with the ISVR, is awarded every year in memory of the late Professor Douglas Robinson, and goes to the writer of the best ISVR MSc dissertation on a topic in the human aspects of sound and vibration or audiology.

Wall vibrations - further research

It gave me much pleasure to see an article in *Acoustics Bulletin* (July/August 2003) relating to the most important branch of acoustics, musical acoustics. The importance of wall vibrations in the performance and assessment of musical wind instruments was a major interest of mine for quite a few years.

However, my delight was tempered when I found that the significant work done by my student Peter Watkinson in the 1980s was not listed in the references. Pete unravelled some of the remarkable claims made about wall material by manufacturers, and also, sadly, by some who claimed to study musical instruments more scientifically; he was able to show how mutually contradictory these claims were.

His major contribution, though, was to apply the methods of finite element analysis to the vibrations of brass musical instrument walls and as a result he could demonstrate quantitatively the effects of the coupling between the vibrating air column and the walls and how critically the magnitude of this coupling depended on structural features of the instrument. I add some references to his work below.

May I congratulate Whitehouse, Sharp and Hill on their work and say how much I look forward to further papers from them.

Dr John Bowsher HonFIOA

Additional references

1. Manufacturers' opinions about brass instruments P S Watkinson and J M Bowsher, *Brass Bulletin 38* (1982).
2. Acoustic energy losses in brass instruments P S Watkinson, R Shepherd and J M Bowsher, *Acustica 51* **213-221** (1982).
3. Vibration characteristics of brass instrument bells P S Watkinson and J M Bowsher *J.Sound Vib. 85* **1-17** (1982).
4. Vibration Characteristics of Brass Instrument Bells J M Bowsher and P S Watkinson *11th International Congress on Acoustics*, Paris, July 1983.

The editor replies:

I am more than happy to acknowledge the contributions of John Bowsher and his colleagues, and delighted to be able to correct the omission here. I know that no slight was intended by Whitehouse, Sharp and Hill, and I too look forward to reading the results of their further researches. I am sure many of my consultancy clients would disagree that musical acoustics is the 'most important branch' of the subject, but equally sure that time and history will prove them wrong!

Acoustic alterations in schools

Research team seeks help

A research team led by Bridget Shield at South Bank University and Julie Dockrell at the Institute of Education is currently investigating the acoustic design of classrooms and the effects on children and teachers of poor acoustics, as part of an EPSRC funded research project. The team would like to know of any primary schools where acoustic alterations are being carried out, in order to do 'before and after' noise, acoustic and questionnaire surveys. If anyone is involved in such work and thinks that the school(s) would be willing to take part in the project, could they please contact Anne Carey at South Bank University on 020 7815 7663 or careyal@sbu.ac.uk.

EXAMINATION RESULTS

Certificate of Competence in Workplace Noise Assessment

The following were successful in the May 2003 examination.

NESCOT
Banks T A
Sykes P
Rabone A
Holmes S T
Ford R C

University of the West of England, Bristol
Bullock B J
Heatman J
Hitchings L
Lomas G
Roberts D K
Shears R P
Taylor B
Watkins N
Avery K S

University of Derby
Kehoe S J
Eames C S
Stubbs N
Tallack M W
Wilson A

University of Glasgow
Campbell H
Forrest E
Gordon M
Kerr H

University of Ulster
Tubridy F
Menihane G J
Memery D
Lane M E
Lane B
Doyle L
Boylan L

Leeds Metropolitan University
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Occupational exposure to vibration

Assessment, control and what the law requires

Chris Nelson MIOA

The need to protect people at work from the harmful effects of vibration is well known, following high-profile compensation awards in the courts, and information campaigns by the Health and Safety Executive (HSE) and others. Exposure to hand-transmitted or hand-arm vibration (HAV) is associated with risks to health - specifically the vascular, neurological and musculoskeletal disorders, collectively known as hand-arm vibration syndrome (HAVS).

A study conducted for the HSE by the Medical Research Council (Palmer *et al*, 1999a) estimated that about 4.8 million people in the United Kingdom are exposed regularly to HAV, including 1.2 million above the HSE's recommended action level, and that about 300,000 people may have cold-induced finger blanching attributable to vibration exposure (vibration-induced white finger or VWF). This is the most common prescribed industrial disease in the United Kingdom, with about 3000 new disablement benefit cases assessed each year by the Department for Work and Pensions.

Exposure to whole-body vibration (WBV) and shock, generally in mobile machinery and various forms of transport, is also associated with detrimental effects on health - particularly back pain, although understanding of this risk is less well developed.

A recent European Directive (European Parliament and the Council of the European Union, 2002) requires EU Member States to introduce implementing legislation by 6 July 2005 on the control of risk from exposure to vibration at work. In the UK, the *Physical Agents (Vibration) Directive* (or, for short, the *Vibration Directive*) will be implemented by regulations made under the *Health and Safety at Work, etc Act 1974.*

Comprehensive guidance on the control of hand-arm vibration in the workplace has been available from the HSE since 1994; the new regulations will build on progress made since then and will require only minor changes to the well-established approach to this subject in the UK. The *Vibration Directive* also includes requirements for whole-body vibration, and the HSE is currently developing its guidance on this subject.

This article discusses the duties of employers to manage vibration at work and considers what impact the new regulations will have. It also considers the approach employers should take to the assessment and control of vibration-related risk, and the role of exposure evaluation.

Employers' duties

Employers have duties to manage the risks to their employees' health and safety under existing general legislation, including the *Management of Health and Safety at Work Regulations 1999* and the *Provision and Use of Work Equipment Regulations 1998.* These duties include:

- assessment of risk;
- planning and implementing control measures;
- providing and maintaining suitable work equipment;
- providing workers with information and training; and
- monitoring and reviewing the effectiveness of the risk control programme.

The 'hierarchy of control' is a concept that is well-established in health and safety management. That which should be followed for the control of vibration exposure is:

- eliminate exposure to the hazard (vibration) by replacing the work process with a vibration-free alternative;
- reduce exposure by modifying the process or reducing the need for it;
- replace tools and equipment with lower vibration types and maintain them correctly;
- train operators to use equipment correctly and safely;

- limit individual daily exposure times; and
- provide health surveillance where risks remain.

The future Control of Vibration at Work Regulations

The Vibration Directive is a 'daughter' of (and is thus compatible with) the 'Framework Directive' (Council of the European Communities, 1989), which was implemented in the United Kingdom by the *Management of Health and Safety at Work Regulations 1999*. The future *Control of Vibration at Work Regulations* will not, therefore, create an entirely new set of duties for employers, but will clarify existing legal requirements as they apply to vibration risks. For hand-arm vibration, employers who are already following the HSE's existing guidance, and working to minimise exposures, should not need to do much more. The Directive defines an exposure action value (EAV) and an exposure limit value (ELV) for both hand-arm and whole-body vibration.

The Physical Agents (Vibration) Directive (Directive 2002/44/EC)

Hand-arm vibration:
Exposure action value (EAV):2.5 ms^{-2} $A(8)$
Exposure limit value (ELV):5 ms^{-2} $A(8)$

Whole-body vibration:
Exposure action value (EAV):0.5 ms^{-2} $A(8)$
or 9.1 $ms^{-1.75}$ *VDV*
Exposure limit value (ELV):1.15 ms^{-2} $A(8)$
or 21 $ms^{-1.75}$ *VDV*

Briefly, the requirements of the Vibration Directive are to:

- reduce vibration risk and exposure to a minimum;
- assess risk and exposure levels;
- when the EAV is exceeded, plan and implement a programme of measures to reduce exposure;
- when the EAV is exceeded, provide appropriate health surveillance;
- keep exposure below the ELV; and
- provide information and training for vibration-exposed employees.

The Directive permits Member States to allow a transitional period of up to five years (nine years for agriculture and forestry) before enforcing the duty to keep exposure below the ELV. The transition period can only apply to work involving equipment supplied before July 2007 and where there is no reasonably practicable means, in the short term, of reducing the exposure sufficiently. The transitional period does not affect duties arising from exposure above the EAV; it does allow employers time to implement changes to their processes or to obtain alternative equipment in the longer term.

Public consultation on implementation

The Vibration Directive must be implemented by 6 July 2005. The HSE has drafted Regulations, which will come into force on that date, together with its revised guidance on hand-arm vibration and new guidance on whole-body vibration. Consultation documents containing the draft regulations and guidance are due to be published in the autumn of 2003. A formal public consultation period will then take place before publication of the Regulations and guidance in their final form.

The consultation period provides an opportunity for employers, trade unions, machinery manufacturers, consultants and other stakeholders to consider vibration exposures and opportunities for control in their industries. The HSE will be inviting comment on how the Directive can best be implemented in the new *Control of Vibration at Work Regulations*, and on the scope and content of the supporting guidance. Responses will be taken into account in the final decisions on, for example, the transitional periods allowed for the ELV and the choice between the two methods for defining the EAV and ELV for whole-body vibration. The HSE is actively looking for evidence-based views and opinions and is publishing regular updates on its vibration web page:
http://www.hse.gov.uk/vibration

Hand-arm vibration

The HSE's current guidance on hand-arm vibration (HSE, 1994) contains a recommended 'action level' for regular daily exposures. Where the action level is exceeded, inspectors expect a programme of risk control and health surveillance to be in place (Nelson & Brereton, 2000).

The HSE has also produced a wide range of additional guidance material, including a book of case studies (HSE, 1997a), leaflets for employers and employees (HSE, 1998a, 1998b, 2001), a video (HSE, 1998c), a multimedia CD-ROM (HSE, 2000) and various industry-specific publications to help duty-holders identify and control risks from hand-arm vibration.

Before 2001, the relevant standards for evaluating exposures to hand-arm vibration were ISO 5349 (International Organisation for Standardisation, 1986) and BS 6842 (British Standards Institution, 1989). These Standards both specified the measurement of vibration at the position of the hand, in terms of a frequency-weighted rms acceleration in three orthogonal axes; the value for the axis with the greatest vibration was used for evaluating the daily vibration exposure. The British Standard defined the daily vibration exposure as the 8-hour energy-equivalent frequency-weighted rms acceleration, $A(8)$ (analogous to the daily personal noise exposure $L_{EP,d}$):

$$A(8) = a_{hw}\sqrt{\frac{T}{T_0}}$$

where a_{hw} is an rms value representative of the day's (highest axis value) vibration magnitude, T is the total daily exposure duration, and T_0 is the reference duration of eight hours (28800 seconds).

In 2001, BS 6842 was withdrawn in favour of BS EN ISO 5249-1 (British Standards Institution 2001). This document

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is a revision of the 1986 version of ISO 5349 and the principal difference between it and BS 6842 is the use of the 'vibration total value', a combination of the three measured single-axis rms values:

$$a_{hv} = \sqrt{a_{hwx}^2 + a_{hwy}^2 + a_{hwz}^2}$$

The *vibration total value*, a_{hv}, is greater than the highest single axis value by a factor of between 1 (where the tool vibration is dominated by vibration in a single direction and the transducer axis is aligned with this direction) and the square root of 3 (where the vibration magnitudes are identical in the three measurement directions).

It has been shown (Nelson, 1997) that for many tools, and perhaps on average, the vibration total value is around 1.4 times the dominant axis value. Consequently, daily exposure values, $A(8)$, based on the vibration total values can be considered, on average, to be greater than their 'dominant axis' counterparts by a factor of 1.4. The HSE's existing action level of 2.8 ms^{-2} $A(8)$ can therefore be substituted by an indicative value of 4 ms^{-2} $A(8)$ (approximately 2.8 × 1.4) for comparison with the exposure criteria in the new Regulations.

The new EAV and ELV lie either side of the existing HSE action level; the numbers of vibration-exposed workers who need to be included in formal programmes of control measures and health surveillance will increase by an estimated 500,000 to 1.8 million in 2005 when the new Regulations come into force. It is estimated that around 900,000 people are currently exposed above the ELV, and some industries will need to use the transitional period to find alternative production methods and eliminate high vibration exposures.

Whole-body vibration

Most occupational exposure to whole-body vibration involves driving: for example, construction and quarrying machinery, agricultural and forestry machinery, industrial trucks, road haulage and public service vehicles. Back pain, and related problems, in drivers may result from a range of ergonomic stresses, including poor or restrained posture and manual handling activities as well as whole-body vibration and shock.

The Vibration Directive specifies whole-body vibration exposure action and limit values using both the $A(8)$ (rms acceleration) method and the vibration dose value (VDV) method. These methods are among several described in ISO 2631-1:1997 (International Organisation for Standardisation, 1997). Member States must select which option to adopt; the HSE has suggested VDV for the EAV and $A(8)$ for the ELV and the decision will be made after the period of public consultation. The options and their implications have been discussed elsewhere (Nelson & Brereton, 2002).

Of the nine million people occupationally exposed to WBV in the UK (Palmer *et al.*, 1999b), it is estimated that around 1.3 million are exposed above the EAV, although many are road vehicle users and are unlikely to be at high risk from vibration. About 200,000 may be exposed above the ELV, mostly in off-road operations.

HSE's existing simple guidance on managing whole-body vibration (HSE, 1997b) takes a qualitative approach to the problem, recommending that employers check that vehicles and suspension systems are correctly selected, maintained and adjusted and that driving behaviour avoids high vibration and shocks. Comprehensive guidance on whole-body vibration, to coincide with the introduction of the new Regulations, is currently being prepared and is likely to recommend a holistic approach to the assessment and control of risk of back pain for drivers. Generic assessments and control expectations may be included for certain industries or activities, if appropriate.

The Vibration Directive specifies hand-arm vibration exposure action and limit values

Assessment and control - first steps

Both current legislation and the future vibration regulations require employers to assess risks from vibration and to take appropriate action to control those risks. This does not necessarily mean that vibration measurements in the workplace are required or that precise personal exposure values must always be determined and documented for all vibration-exposed employees; nor should assessment be considered as a 'stand alone' exercise, divorced from control planning and implementation.

It may be tempting for employers to start with the question: '*What are the vibration exposures of my employees?*' and to embark on a costly and time-consuming programme of measurements before taking any action to reduce the risk of injury. In fact, the risk assessment can begin with the simple question '*Is there a problem?*' For HAV the answer is likely to be '*yes*' if there is regular or prolonged exposure of operators' hands to vibration, particularly in industries, or for processes, with a history of HAVS.

As a rule of thumb, it should be assumed that there is a vibration problem to be managed for:

- the use of a percussive tool (eg breaker, chipping hammer) for more than a few minutes per day; or
- the use of a rotary tool (eg a grinder or sander) for more than about half an hour per day.

(For WBV, generic information on the likely range of exposures should become available for many common driving operations, as industry prepares for the new Regulations.)

The second question should be '*What can be done to eliminate or reduce the risk?*' The most satisfactory answers will often come from someone who is familiar with the industrial process in question, rather than a 'vibration expert' (for example, one foundry has virtually eliminated vibration exposure from grinding excess metal from cast pipe components by improving the casting process so that

the product requires little or no fettling; this improvement required knowledge and understanding of foundry processes, rather than vibration expertise).

More commonly, and particularly in the shorter term, ensuring the use of suitable and up-to-date tools and equipment will be an effective way forward, as many recent types of power tool produce lower vibration emissions than older models. Manufacturers or suppliers of the machinery producing the vibration are important sources of information for employers. They have duties under the European Machinery Directive (Council of the European Union, 1998), implemented in the UK by the *Supply of Machinery (Safety) Regulations 1992* (as amended) to:

- design and construct machinery to the state-of-the-art for safe operation; and
- provide instructions that include warnings of any residual risks (including those from vibration), so that employers can comply with their own duties to provide their employees with safe equipment, and to manage its use safely.

Discussions between tool manufacturers and their customers regarding vibration risk and its management should identify:

- any unusually high or low risk tools and the right tool for the job;
- the range of likely vibration emissions when a tool is used for the tasks envisaged;
- an estimate of daily exposure;
- maximum daily operating duration;
- modes of operation that should be avoided because they increase vibration exposure, or favoured because they decrease vibration exposure;
- any training requirements for safe operation; and
- maintenance programmes to prevent increased vibration.

Quantifying exposure

Employers need to be aware of the likely daily vibration exposures so that they can compare them with the exposure action or limit values and decide on the need for action. It is often possible to achieve this with sufficient accuracy, using existing available information on vibration magnitudes.

EXAMPLE:

A worker removes paint from a steel structure using an old needle scaler for about one hour a day. Published data shows that the vibration magnitude in a similar operation with this type of tool was in the range 12-18ms^{-2}. This means that his daily exposure is likely to be between about 4 and 7 ms^{-2} A(8), well above the exposure action value (EAV) of 2.5 ms^{-2} A(8) and thus requiring control. The employer may decide that the needle scaling process can be replaced by an alternative such as grit blasting or water jetting, eliminating vibration altogether. Alternatively, he might decide to replace the tool with a modern vibration-reduced type, for which the manufacturer provides information showing that the tool typically produces vibration magnitudes in the range 3 – 6 ms^{-2} when performing an equivalent task. The worker's exposure is now likely to lie in the range 1 – 2 ms^{-2} A(8) and so will be below the EAV. The employer has been able to decide on an appropriate action plan without needing to find out the 'exact' exposure.

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In addition to the duties already mentioned, manufacturers and suppliers of power tools and mobile machines have a duty in the Machinery Directive to declare vibration emission values measured using the appropriate harmonised test code. The Vibration Directive shows a link with the Machinery Directive where it says that employers could use manufacturers' information when making their exposure assessments.

Research for HSE has shown that some vibration test codes for power tools (such as the EN ISO 8662 series of standards) produce emission values that are poorly correlated with the vibration in real use (Pitts, 2003). The HSE is using research evidence to press for improvements in these test codes so that the emission values provide an adequate warning of risk; this is an on-going process that will take several years.

It is clear that, for some categories of tool, use of the declared standard emission values for estimating exposures would carry large uncertainties and could fail to warn of risk. However, suppliers are also expected to provide the necessary information so that employers can manage any residual risks. This should include realistic data on vibration and the HSE is working with machinery suppliers to improve the quality of this information (Brereton, 2001).

There are other sources of information on vibration magnitudes that can be used to estimate daily exposures. Increasingly, trade associations are coordinating the collection of data from vibration surveys for the benefit of their members who may be using similar machinery for similar purposes. Some organisations are providing databases of vibration magnitudes (including both manufacturers' emission values and 'real world' measurements. Two such databases can be found on the internet at:

http://umetech.niwl.se/Vibration/HAVHome.html

http://www.liaa.de/karla (currently in German, but an English version is planned)

Measuring vibration

Vibration measurement in the workplace has a role to play in the identification, control and management of vibration risks. However, measurement of vibration is difficult and uncertainties can be large (Pitts, 2003).

Employers should not assume that they must make their own measurements (or pay a consultant to do so) if the necessary information on vibration risk is available elsewhere. There are, however, some circumstances where vibration measurement in the workplace can be useful, eg:

- where suitable vibration information is not available from the equipment manufacturer or another reliable source;
- when a machine is used in a novel way, unforeseen by the manufacturer, for which no vibration data are available; and
- if, with measures to control vibration in place, it is not clear whether the risk is adequately controlled, and whether further action or health surveillance is required.

Where workplace vibration measurement is undertaken, there will be many sources of uncertainty. The precision with which an instrument can determine a vibration magnitude should not be confused with the accuracy with which a measured value represents the average vibration to which the operator is habitually exposed. It is important to have an understanding of the accuracies and uncertainties and these issues are considered by Paul Pitts, in the article which follows.

Exposure evaluation will often be satisfactorily achieved without measurement on the job

Conclusion

Vibration, like any other hazardous agent, must be assessed and controlled by employers, under existing health and safety legislation. Since the HSE published guidance on hand-arm vibration in 1994, a greater awareness of the risk, and the increasing availability of vibration-reduced tools, have contributed to an improvement of risk control in many parts of British industry, although many workers remain with regular high exposures to vibration. The legislation and supporting guidance, to implement the Vibration Directive in 2005, should encourage continued progress in reduction of exposure and risk through changes to work processes, use of the appropriate equipment and management of residual vibration exposures. It will also raise the profile of whole-body vibration and related ergonomic factors associated with back pain in drivers. The HSE will welcome responses to its Consultative Documents on the form and content of the draft regulations and draft guidance on HAV and WBV.

Vibration exposure assessments are required to identify and prioritise the need for control actions and health surveillance. The assessment must be fit for purpose; identifying exposures that are likely to exceed the action or limit values and informing the planning and execution of risk control measures.

Exposure evaluation, whether using field measurements or existing data, is subject to large uncertainties, and these must be recognised. However, precise exposure values are not generally required and exposure evaluation will often be satisfactorily achieved without the need for measurement of vibration on the job.

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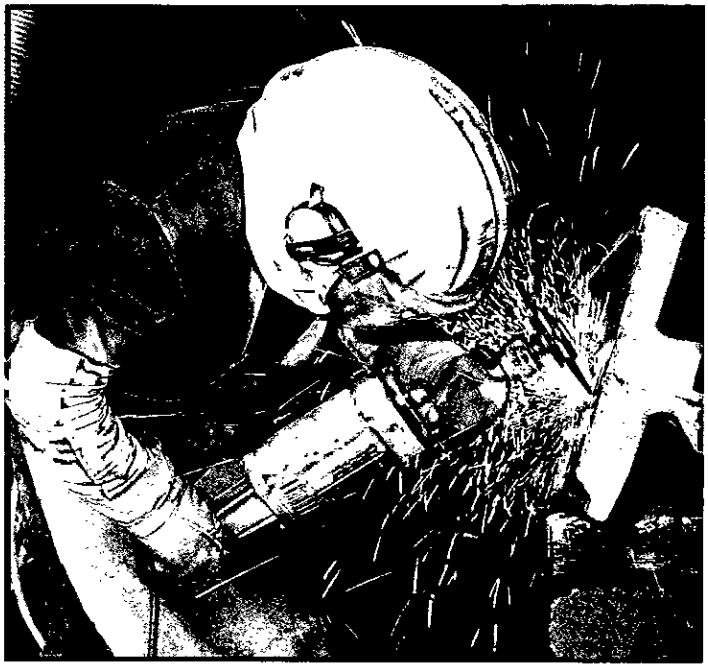

Uncertainty in evaluating exposure to hand-transmitted vibration

Paul Pitts MIOA

The assessment of exposure to hand-arm (or hand-transmitted) vibration is a requirement of the new EU directive on Physical Agents (Vibration). It is important to recognise that assessment of exposure does not necessarily mean that there is a need to measure vibration, and that there is a process that should be used which may avoid the need for direct measurement. This process was discussed by Chris Nelson in the preceding article.

The process of assessing vibration exposures starts with simple 'rule-of-thumb' evaluations that may, if necessary, lead through to detailed measurement of exposure. At each stage in this process, it is important to understand the sources and effects of uncertainties in the assessment procedures.

The purpose of this article is to review the processes of evaluating hand-arm vibration exposure, identify possible causes of uncertainty in the assessment of vibration, and suggest means by which these uncertainties may be reduced. The article draws upon work on the accuracy of hand-arm vibration measurement carried out by the Health and Safety Laboratory (HSL) for the Health and Safety Executive (HSE).

Vibration exposure assessment based on manufacturers' declared vibration emission values

Vibration emission data

The EU Directive on Machinery Safety 98/37/EC (the 'Machinery Directive') requires that manufacturers or suppliers of hand-held or hand-guided machinery provide information on the risks from hand-arm vibration. One requirement of the Machinery Directive is the declaration of the actual frequency-weighted acceleration value if that value exceeds 2.5 ms^{-2} rms.

Normally manufacturers obtain vibration emission values based on standardised test codes. For hand-held power tools, these tests are usually defined in either the BS EN ISO 8662 series of standards (for pneumatic tools) or the BS EN 50144 series (for electric tools). Other tools have their own standards, for example, chain saws (ISO 7505) and brush-saws (ISO 7916).

Estimation of daily vibration exposure

Standardised emission tests are designed to produce emission values that are reproducible by different laboratories. For this reason, the tests are often based on artificial use of the power tool. This artificiality can mean that the emission results are a poor reflection of the vibration values seen when a tool is in real daily use.

Work by HSL has shown that the relationship between manufacturers' vibration emission values and the vibration values found during measurements in the real workplace can be poor. *Table 1* summarises results from a series of HSL projects looking at the relationship between emission data and in-use vibration for pneumatic power tools.

Table 1 shows that with current emission standards, vibration exposure assessment based on manufacturer-declared vibration emissions is subject to a large uncertainty.

Residual risk data

The Machinery Directive requires manufacturers, or suppliers, to provide information on any residual risks. For power tools, residual risk information may be necessary where vibration emission values do not reflect the likely vibration levels expected during normal use of a machine.

Power tools may be designed for a variety of applications that generate different vibration levels, or they may be used on a range of materials or with a range of different accessories. The wide range of application of power tools can affect the vibration levels experienced in use. In some cases, residual risk information may provide a better basis for estimating vibration exposure than the declared vibration emission values.

Vibration exposure assessment based on measurement

Direct measurement of vibration values from a tool in use is the method that should give the most reliable assessment of daily vibration exposure. For successful measurement, it is important to understand what influences the accuracy of vibration measurement and how to minimise uncertainty

Sources of uncertainty in vibration measurement

Sources of uncertainty in assessing daily vibration exposure can be divided into five groups, relating to:

i) **Instrumentation** - the influence of the instrumentation, from mounting system to measurement instrument, on the accuracy that can be achieved;
ii) **Measurement process** - factors relating to the mechanics of performing a measurement on the vibration magnitude measured, such as the selection of measurement periods, the locations of transducers;
iii) **Exposure-time assessment** - the effect of the method of assessment of exposure-time on the estimate of daily vibration exposure;
iv) **Tool or machine** - changes in the tool as it is used, eg. wear of abrasives or cutting edges, and the warming up of components and lubricants within the tool;
v) **Operator** - factors relating to the operator of the tool such as their skill, technique, experience, training, and motivation;
vi) **Task** - changes in the task being assessed, ie. whether the sample measurement can be assumed to be representative of a whole day's work.

Assessment uncertainties cannot be avoided, but a good understanding will enable them to be controlled.

ISO Standard	Tool type	Correlation coefficient	Ranking coefficient	Does emission indicate the in-use vibration?	Other comments
8662-2	Chipping hammers and riveting hammers - *Chipping Hammers*	Correlation poor (0.5)	Rank good (0.9)	Underestimates vibration in real use.	Riveting hammers were not included Feed force too high for some tools. No measurements on foremost hand position or chisel
8662-3	Rock drill and rotary hammers	Correlation good (0.9).	Rank good (0.9).	Emission data estimates vibration in real use	Axis of greatest vibration not always the test axis (varied with operator) Handle of greatest vibration not always the test handle. Performance varies considerably. Efficiency test required.
8662-4	Grinders	Correlation poor (0.1)	Rank poor (0.5).	Underestimates vibration in real use.	Transducer position does not reflect real use.
8662-5	Pavement breakers and hammers for construction - *Breakers*	Correlation poor (0.4)	Rank good (0.9)	Does not give data indicative of range of real use.	Often the major source of vibration for these tools is the off-load running which is not taken into account in the test. The large spread of field data is not taken into account in the standard.
8662-5	Pavement breakers and hammers for construction - *Hammers*	Correlation poor (0.1)	Rank poor (0.2)	Does not give data indicative of range of real use.	
8662-6	Impact drills	Correlation poor (0.5)	Rank good (0.8)	Does not give data indicative of range of real use.	Spurious results seen Axis of greatest vibration not always the test axis Large variation in field vibration data (material, drill bit) Large variations can be seen between operators for certain tools.
8662-7	Wrenches, screwdrivers etc			Gives an indication of real use	Only one tool assessed.
8662-8	Polishers and rotary sanders			Underestimates vibration in real use	Limited study Accelerometer position interferes with operation. Vibration in the finger can be greater than in the palm. Feed force is critical. Vibration varies between operators.
8662-9	Rammer	Correlation good (1.0)	Rank good (0.9)	Good indicator of real use	Feed force does not reflect typical operation especially for large tools.
8662-11	Fastening driving tools *-nailers*				Operating rate does not reflect real use.
8662-14	Stone-working tools and needle scalers	Correlation (0.7)		Underestimates vibration in real use	No measurement on chisel.

Table 1 Summary of the relationship between emission data and in-use vibration for pneumatic tools

Instrumentation

Instrumentation for the measurement of human exposure to vibration should conform to the requirements of ISO 8041:1990. This standard places basic mechanical and electrical sensitivity requirements on the vibration instrument. For a correctly calibrated instrument and transducer it is expected that the typical uncertainty of measurement for a real vibration signal under ideal conditions will be ~ ±4%. This uncertainty may increase to ~ ±10% for highly sinusoidal signals at the extremes of the frequency range.

Field calibration - when using a vibration meter, a sensitivity check procedure should be carried out before and after all sets of measurements. This check will rely on a vibration 'calibrator' (a misnomer, since the purpose of the calibrator is generally not to calibrate but rather to check the instrument's sensitivity is within an acceptable range). The 'calibrator' should itself be calibrated on a routine basis, and the stated output will be given a tolerance which is typically ~3%.

The calibrator provides a test signal at one frequency (usually either around 80 or 160 Hz), however, the sensitivity of vibration transducers is frequency dependent, around -2% per decade being quoted by manufacturers. Overall this frequency dependence will introduce an uncertainty of typically ~+2.5% -0% in the measured frequency weighted acceleration value.

Transducers - the vibration characteristics of power tools, and particularly impactive tools, require transducers and instrumentation capable of operating over a very wide amplitude and frequency range. Although the hand-arm vibration frequency range is no higher than 1500 Hz, and the frequency weighted vibration magnitude is unlikely to exceed 30 ms^{-2}, the unweighted vibration signal may include shocks exceeding 100,000 ms^{-2} peak that may

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Uncertainty in evaluating exposure to hand-transmitted vibration

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contain energy at frequencies of several tens of kilohertz.

High-amplitude, high-frequency signals challenge the ability of any vibration transducer and measurement instrument to produce valid frequency-weighted acceleration values. Instruments and transducers with insufficient amplitude ranges may be incapable of determining accurate frequency weighted results, since the important low-frequency components of the vibration signals will be lost in the instrument's electrical noise floor.

Piezoelectric transducers offer large measurement ranges compared with other transducer types, and are therefore a natural choice for hand-arm vibration measurements. Unfortunately, piezoelectric transducers are susceptible to 'DC shift', a distortion that grossly affects hand-arm vibration measurements (see BS EN ISO 5349-2:2002). Piezoelectric transducers generate charge signals, which means that it is important to use charge amplifiers and good quality cables in good condition.

It is now common to find vibration instruments supplied with transducers featuring in-built amplifiers and signal processing ('active transducers'). This has the advantage that the transducer output is a voltage, which does not need expensive cables and connectors. However, the maximum amplitude and the overall measurement range of active transducers are predetermined by the characteristics of the in-built electronics. Currently available active transducers do not have the amplitude range necessary for general workplace hand-arm vibration measurement and are susceptible to overload when used with percussive tools.

Cables and connectors - triboelectric effect can occur when the screening of a coaxial cable becomes momentarily separated from the dielectric at points along its length as a result of bending or other stresses. This separation causes local changes in capacitance and charge between the signal carrying cable and its shield. The charge generated in the cable by the triboelectric may be indistinguishable from the existing charge generated by the piezoelectric accelerometer and can be mistaken for a low frequency vibration signal. The likelihood of error due to the triboelectric effect is dependent on the quality and maintenance of cables and how well cables are routed and secured during a measurement.

With high quality cables triboelectric signals are unlikely to be sufficient to have any effect on the frequency-weighted signal from a power tool measurement. However, poor quality or damaged cable can produce high levels of apparent vibration when vibrated. Similar problems are often encountered with poor cable connectors. Where possible, cable-to-cable connections should be avoided or positioned away from the sources of vibration.

Measurement Process

There are a number of measurement uncertainties arising from the process of carrying out a hand-arm vibration measurement in a real workplace.

Measurement duration - the selection of representative periods of work for sample measurements is covered in BS EN ISO 5349-2:2002. In many cases, the selection is a matter for judgment based on careful observation of the tasks being carried out, questioning of the workers, a knowledge of the machines and tools being used and experience.

It is recommended that measurement durations are as long as possible. For hand-arm vibration, the work process often determines measurement duration. A measurement can only last while the machine operator continues to hold the machine; once contact is lost, the machine's vibration is no longer affected by the hand and grip and if the machine continues to operate the measured vibration will often increase dramatically. In practice, measurements often have to be performed as a series of short-term samples, which are combined to produce an average vibration value. Investigation of this type of sampling has shown that there is a tendency to under-assess the amount of time the tool is switched off, idling or running up or down. Since these operations are generally lower-vibration modes the vibration values from short term sampling tend to overestimate the true long-term average value by as much as ten percent.

Electrical pickup - for measurements on power tools, the most convenient routing for signal cables is often along the air supply hose or power cable. For pneumatic tools, this does not present a problem. However, for electrically powered tools there may be a degree of electrical pickup from the power cable. Generally, the advice is to minimise the length of signal cable that has to run along a power cable, although tests attempting to generate electrical pickup in good quality signal cables showed no detectable change in the measured vibration signal.

Mounting - the single biggest source of uncertainty in vibration measurement can be the mounting system used to connect the vibration transducer to the vibrating surface. A variety of mounts is used for vibration measurement, often with little understanding of their potential effect on the measured vibration value.

Ideally, the transducer mount should be small, lightweight and rigidly fitted to the vibrating surface. The effectiveness of a mounting system can be seen by looking at its frequency-response, which is obtained by simultaneous measurement of the output from a transducer attached by stud directly to the vibrating surface and the output from a transducer fitted to the mount, see *Figure 1*.

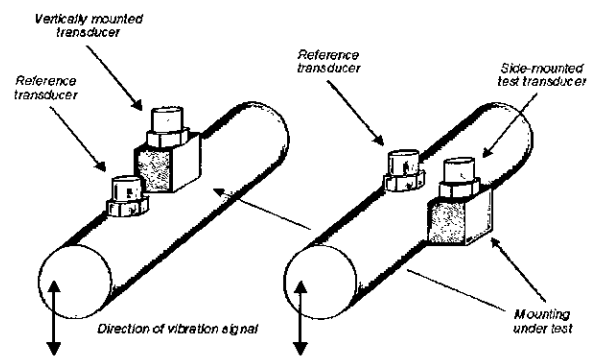

Figure 1 Frequency response test set up

Figure 2 shows the examples of the results from some commonly used mounting systems and illustrates a number of issues relating to rigidly mounted transducers and hand-held transducer mounts.

For rigidly mounted transducers: the response of a rigidly

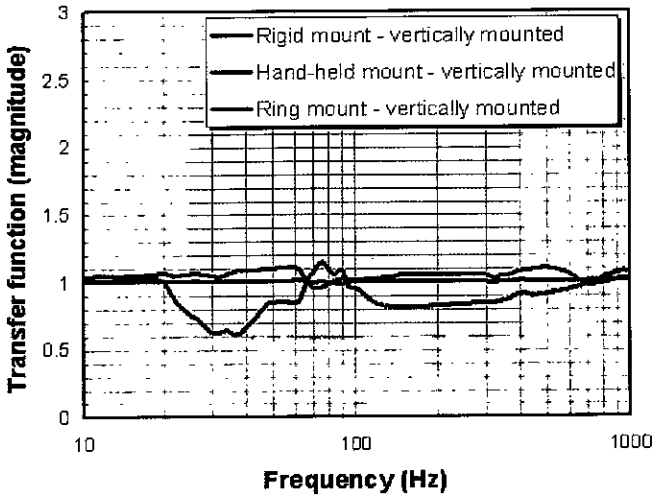

Fig 2a: Transfer functions for rigidly mounted transducers and two types of hand held mounts, vertically mounted

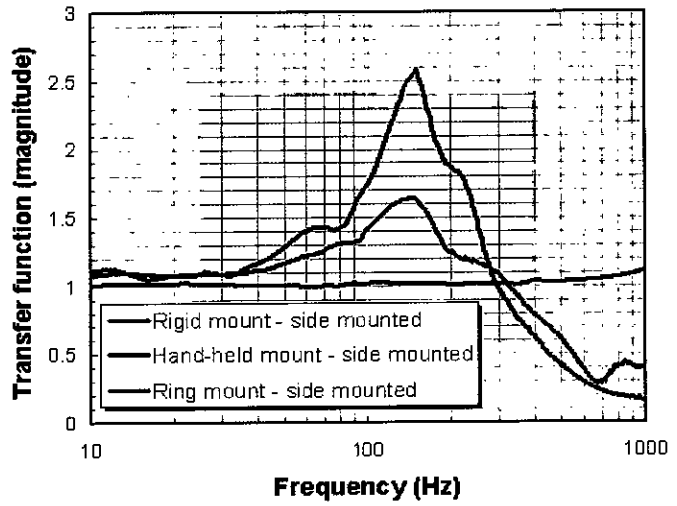

Fig 2b: Transfer functions for rigidly mounted transducers and two types of hand held mounts, side mounted

mounted transducer is close to unity at all frequencies and in all mounting orientations. (The mount used to generate the data in *Figure 2* used a mechanically tensioned nylon cable tie system to strap a cubic, aluminium, mounting block to the test handle.)

For hand-held transducer mounts: the response is poor in all directions, even at relatively low frequencies. There is amplification of the vibration by a factor of more than 2 at frequencies between 100 and 200 Hz, frequencies that are associated with the rotational speeds of many power tools. (The mount used here was a 'through-the-fingers' design, with the transducers actually sited above the knuckles of the fingers.)

For ring transducer mounts: the mount has a poor off-axis response, but can provide adequate coupling when the transducer is mounted in-line (vertically on a vertically operating tool). With the mount and the dominant vibration axis aligned, the response can be close to unity over a wide frequency range. (The ring mount used here was an aluminium ring designed to fit on the middle section of the middle finger. The vertical transducer is glued on top of the ring; the others are mounted close to its base.)

Clearly, the use of hand-held mounts should be considered carefully. Where there is a very dominant single axis vibration, and where the hand-held mount can be positioned to be in-line with that vibration, the hand-held mount may provide reasonable results. While mounting

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systems with poor frequency response cannot be generally recommended, there are occasions where hand-held mounts are the only means of obtaining any measurements. In such situations, the mounting system must be arranged such that the in-line result dominates the overall vibration value, this will ensure that the overall result has the lowest possible measurement.

Some hand held mounts, such as the example used in the tests for *Figure 2*, feature posts that feed between the fingers, allowing the transducers to be located above the fingers. This type of mount increases the distance between the transducer and the vibrating surface and thus amplifies rotational vibration components. Generally, transducers should be mounted as low as possible on the vibrating surface.

Mechanical filters

Mechanical filters reduce the effects of the unwanted high frequency vibration from impulsive tools or other impulsive vibration sources by preventing them from exciting the mounted resonance of the piezoelectric transducer. Excitation of the mounted resonance of the piezoelectric transducer, particularly by short duration repetitive signals, can cause DC shift distortion. The mechanical filter is a low pass filter that attenuates the frequencies that can cause DC shift without influencing vibration in the frequency range of interest (ie. below about 1500 Hz).

Much concern has been expressed concerning the transverse performance of mechanical filters on impactive power tools, ie. measuring in directions orthogonal to the direction of strike. It is assumed by some that the mechanical filter is:

a) not required - because the vibration magnitude is not high enough to cause DC shift problems; and

b) not desirable - because the dominant axis vibration will induce rocking of the transducer on its resilient mount, producing erroneously high vibration measurements.

However, it is clear that DC shift can occur on the off-axis directions of tools when used for real applications and in such situations, mechanical filters are necessary to get any measurement.

Assessment of the transverse performance of mechanical filters is difficult. However, comparative measurements with a laser-doppler transducer showed no apparent affect of the mechanical filter on the frequency-weighted vibration, right up to the level at which DC shift occurred.

Transverse response of the transducer - on impactive tools, the measurement of vibration may be affected by the transverse response of the transducer, typically around 3% for hand-arm vibration accelerometers. This could lead to over-reading the vibration magnitude by up to 4%.

Location of transducer - the choice of location of the transducer for a vibration measurement can have an important effect on the result of the measurement. Work by Nelson (1991) showed that the vibration magnitude along a grinder handle could vary by as much as 100%.

It is important to describe clearly the location chosen for vibration measurements. BS EN ISO 5349-1:2000 identifies the correct measurement location as being the centre of the hand. For tools with anti-vibration handles BS EN ISO 5349-2:2001 recommends that, where measurements near the centre of the hand are not possible, measurements are made at both ends of the hand grip region. This allows a simple average to be used as the estimate of the vibration at the centre of the hand (recent work at HSL has shown that lightweight handles can have complex vibrational modes that make such simple averages invalid). Where measurement can only be taken at one end of the hand it is preferable to take the case that is likely to be worst, for example, measuring at the free end of the side handle (usually adjacent to the little finger).

Uncertainty in exposure-time assessment

Assessment of exposure time is the area where there is probably the most scope for variation when assessing an individual's daily vibration exposure. There are several techniques by which exposure time can be estimated and each technique has its pitfalls.

Video monitoring - the use of video can, in principle, accurately assess exposure-time to 1/25 second over a working day. In practical use, such techniques are used for a limited period and in conjunction with other methods to obtain a detailed assessment of daily exposure.

The accuracy of the method will depend on for how long a task is monitored and how valid that period is as a representation of the full working day. Typically, the exposure might be assessed to the nearest frame (1/25 second) over a period of five minutes, giving an uncertainty in the exposure time during that five minutes of better than ±0.01%. However, this exposure time information is then likely to be used in conjunction with one of the other techniques discussed here to assess overall daily exposure times.

Number of components or work cycles - this technique involves estimating the exposure time by counting the number of components processed or the number of work cycles completed during a particular time period or shift. Video recording or work-study records may be used to assess the normal work patterns. When production figures can be obtained, this provides useful information to enable the accurate assessment of exposure durations.

In any assessment of numbers of work cycles or components, it is important to ensure that the records being provided by either site management or work force are appropriate to the real exposure patterns. For example, production records may not recognise rejected products and therefore underestimate the actual numbers processed.

The uncertainty associated with this method will depend on the cycle time per component and the variability in the characteristics of each component. This technique works best when there are large numbers of components or work cycles. For an application, where there are 50 to 100 components, the uncertainty is likely to be less than ±10% for estimates that are based on production figures (assuming the rejection rate is less than 10%).

Activity sampling - activity sampling uses a statistical approach to provide an estimate of the time spent carrying

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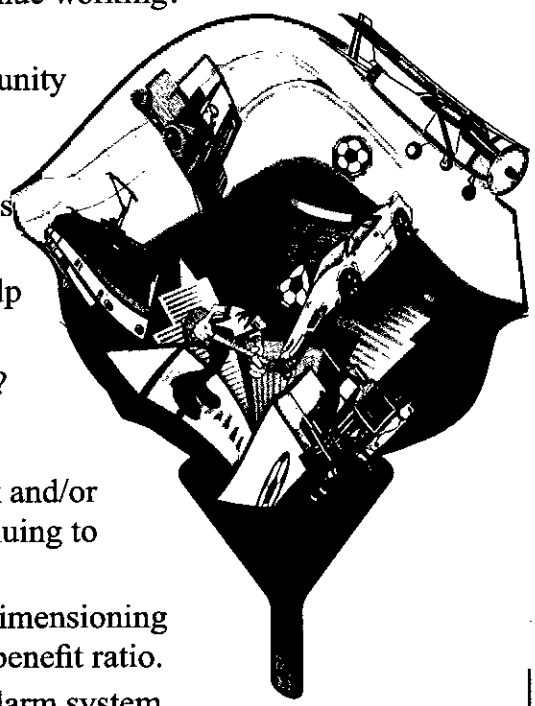

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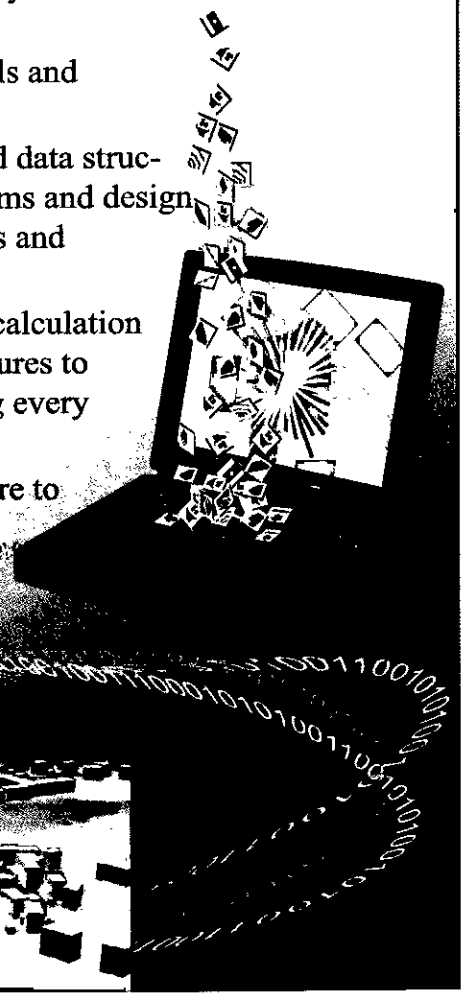

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one of a range of possible tasks. The process involves observing the operator on a regular basis throughout the working day and noting the task being carried out at that time.

The accuracy of this technique will depend on the time interval between samples and the degree of variability within task. There is also the potential for a systematic error due to aliasing, if the task is cyclic and the chosen sampling time interval does not take this cycle period into account.

Activity sampling is probably best with tasks where there are few modes of tool operation and shortest tasks take longer than the sampling period.

Noise dosemeter technique - a study by Teschke *et al.* (1990) presented a technique that used noise dosimetry as a means of monitoring the vibration exposure of chain saw operators. They showed that different sound pressure levels recorded by the dosemeter were representative of the different operating modes of the saw. They compared estimates of exposure time with exposure time actually observed used as a reference and found that the average error in this technique was less than 20%.

Self estimates - a study by Tominaga (1982), comparing self-estimates of exposure time with time and motion studies of the actual exposure time, showed that a tool operator generally overestimates exposure by a factor of two. However, another study by Nilsson *et al.* (1989) showed that although there was a tendency for large variation between subjective and objective measures on an individual basis, there was some agreement between estimated and measured exposure time when the group of twelve platers studied was considered as a whole.

Virokannas 1995 investigated the dose response relationship for railway workers and lumberjacks and gives figures from self-estimates of exposure time of 8050 ± 3500 hours (±43%) for railway workers and 21250 ± 10950 (±52%) hours for lumberjacks.

A study by Palmer *et al.* 2000, showed that workers overestimated their exposure times by a median factor of 2.5 (inter-quartile range from 1.6 to 5.9), with periods of continuous exposure being estimated more accurately than periods of intermittent exposure.

Uncertainty in assessment of daily exposure

The daily vibration exposure, $A(8)$ is related to the frequency-weighted vibration total value, a_{hv}, and the total daily exposure time, T, by:

$$A(8) = a_{hv}\sqrt{\frac{T}{T_o}}$$

Where T_0 is the reference duration of eight hours (28800 seconds).

From this it can be shown that, based purely on the uncertainties due to the measurement process, the overall percentage uncertainty of an $A(8)$ evaluation $p_{A(8)}$ is given by:

$$p_{A(8)} = \sqrt{p_{ahv}^2 + \frac{p_T^2}{4}}$$

Where p_{hv}, and p_t are the percentage uncertainties of a_{hv} and T.

This relationship between the percentage uncertainties highlights the importance of accurate assessment of acceleration magnitude and the lesser importance of the assessment of exposure time.

Estimation of uncertainty - it is difficult to put a specific value of the general uncertainty of a hand-arm vibration measurement and subsequent assessment of daily vibration exposure. Some features of measurement and assessment systems, such as calibration and signal processing, have reasonably consistent uncertainties irrespective of the measurement system. The uncertainties of features such as accelerometer mounting systems and measurement location are not consistent across measurement systems, and yet potentially contribute most to overall uncertainty.

In *Table 2* estimates are put on the typical uncertainty of the

Table 2 Indicative uncertainty values Mechanical filters

Parameter	Uncertainty	Estimate of typical uncertainty (%)	
		Best practice	Handheld mounts
Instrumentation			
Accelerometer Calibration (at reference)	±3%	±3	±3
Accelerometer frequency response	±2.5%	+2.5, - 0	±2.5
Instrumentation	±4%	±4	±4
Measurement process			
Measurement Duration	+10, -0%	+10,-0	+10,-0
Triboelectric effect	Negligible	±2	±2
Electrical pick up	Negligible	±2	±2
Mounting - rigid mount	Negligible	±2	-
Mounting - handheld mount	+100, -50%	-	+100-50
Mass of transducer(s)	Negligible	±2	±2
Transverse response (with or without mechanical filters)	+4, -0%	+4, -0	+4, -0
Location of transducer	+100, -50%	±15	±15
Exposure time measurement			
Video monitoring	Negligible	±2	
Number of components from production records	~ ±10%	±10	
Number of components by video	~±2%	±4	
Activity sampling	Variable	±10	
Noise dosemeter	±20%	±10	
Self-estimates	+60, +490%	(It is assumed that this method is not used)	
Estimated overall typical percentage uncertainties based on typical uncertainties above			
Acceleration magnitude, a_w:		+20, -17%	+102, -53%
Exposure time, t:		±18%	±18%
Daily vibration exposure A(8):		+22, -19%	+102, -53%

various parameters: from these the overall uncertainties of the assessment of vibration magnitude, exposure time and resultant daily exposure, A(8), can be estimated.

The analysis of overall uncertainty in *Table 2* assumes that certain features of the evaluation process have been well controlled; for example, it is assumed that a self-assessment of exposure time is not used. If a hand-held mount were to be used, the uncertainty due to this is likely to dominate the uncertainty in a_{hv}, and the uncertainty in $A(8)$.

The analysis in *Table 2* suggests typical overall uncertainty for best practice evaluation of $A(8)$ of +22, -19% (with the uncertainty of a_{hv} of +20,-17% and uncertainty of t of ±18%). This value is consistent with the range indicated in BS EN ISO5349-2: 2002, where experts estimated typical uncertainties on $A(8)$ values to be in the range 20 to 40%.

Conclusions

The quantification of vibration exposure may be carried out at different levels of confidence, ranging from crude rule-of-thumb indicators, through estimates based on emission data from manufacturers to evaluations based on field measurement. In all cases, it is important to be aware of the impact of uncertainty on the resultant exposure value.

In this article, the uncertainties due to the measurement process have been considered. It is important to recognise that there are additional uncertainties relating to how well the measurement sample reflects a full day of normal working. Issues such as worker fatigue, motivation, experience and skill can all influence the assessment of daily vibration exposure.

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LOUD

Richard Watson AMIOA analyses t
attitudes towards entertainment b
especially in the

It is well documented that hearing can be irreparably damaged by exposure to noise. This damage can result in a number of conditions including tinnitus and noise induced hearing loss. The latter is typified by a dip in hearing sensitivity, particularly at around 4kHz. These frequencies are important for speech discrimination, and therefore a loss in this range is particularly unpleasant.

Noise induced hearing loss causes a permanent threshold shift in aural response. Loss can occur either traumatically or chronically. High intensity sound can damage the eardrum, ossicles and sensory hair cells. This sound can also cause partial collapse of the organ of Corti. Trauma hearing loss is brought on suddenly and therefore a particular noise event may be identified as responsible for the damage.

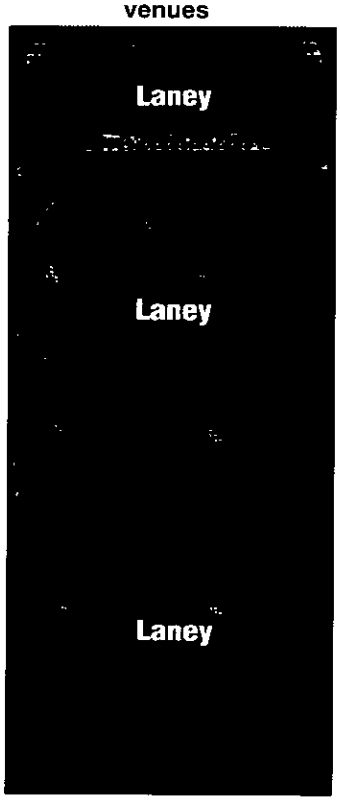
However, noise levels below those associated with trauma damage can still be damaging. If these noises are repeated often enough, or occur for a long enough time, damage may occur. The damaging noise may cause the destruction or malfunction of the sensory hair cells. This type of damage often goes unnoticed, as individuals tend to be unaware of the slowly increasing loss in their audiometric response.

Sound pressure level and exposure time are the most commonly used parameters when determining whether a listener may suffer permanent hearing damage. However, as each individual has different tolerances to noise, it is difficult to evaluate damaging conditions quantitatively.

Legislation is in place, including acts such as the *Mines and Quarries Act 1954, Health and Safety at Work Act 1974* and the *Noise at Work Regulations 1989*, to protect workers from noise in the workplace. More European legislation is also in hand to further control noise levels within the workplace.

Employers are required to protect workers, and in cases where they have been negligent successful action has been taken in the courts. Noise at work will never be eliminated, however, the majority of employers take their responsibilities seriously and consequently working environments are now much safer. Although noise at work has become less dangerous over time, on the other hand entertainment based noise has become a greater danger.

Very powerful audio systems are installed in many entertainment venues



Concerts, night-clubs, pubs, bars and even cinemas now tend to have very powerful audio systems installed. With the increasing capabilities of these sound systems, the noise level experienced inside night-clubs and music venues in particular, are potentially damaging and are likely to exceed 95dB(A). Many papers have been written on this subject and assessments made in terms of level, likely exposure, threshold shifts, knowledge and so on. The *HSE Research Report* **(1)** is a useful document, reviewing much of the literature on the subject.

This article is an attempt to reveal how the recipients of this type of noise feel about the potential hearing damage which may occur.

In order to investigate the attitudes and opinions held by the public (young people in particular), with regard to entertainment based, noise induced hearing loss, semi-structured interviews and focus groups were used in order to probe key areas. However, participants were free to talk about any aspects they found important. Key areas included the interviewee's awareness of this type of hearing loss, their belief as to whether or not they were at risk, and determining if they had ever taken precautions in order to minimise risk.

The original work was undertaken at Salford University. Because the University has a number of acoustics-related courses, the sample group could be selected to include both acoustical and non-acoustical students. Acoustically aware and unaware individuals were assessed in an attempt to discover whether or not education plays a role in combating noise induced hearing loss. Those who are acoustically aware might perhaps take better care of their hearing.

Data was collected from three focus groups and twenty interviews. This generated masses of data which cannot all be presented. The extracts given below focus on key findings regarding the attitudes and opinions of a specific sample of people towards entertainment noise.

Semi-structured interviews

Many topics and issues were explored in the semi-structured interviews. Key data is collected into a number of subjects and displayed below.

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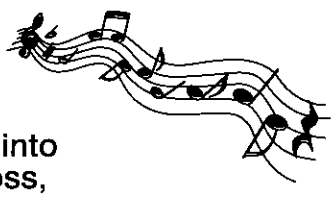

ne findings of an investigation into ased noise-induced hearing loss, 18-30 age group

Education

The role advertising and education plays in other risk activities, such as smoking and drink driving, was often discussed. Interviewee 10 was typical in his responses in that he felt that education and advertising makes a small difference in the attitude of the public towards smoking, but plays a large part in altering attitudes towards drink-driving.

The interviewee was then asked. *"Do you think that increased education and advertising about noise induced health issues would alter the behaviour patterns of the general public?"* The participant responded: *"Some people won't take it seriously. It will make people more aware, but it probably won't change attitudes and behaviour dramatically. It'll be more like the smoking campaign than the drink-driving one".*

A non-acoustically aware participant, interviewee 6, when asked: *"Do you understand why your ears ring after exposure to loud noise?"* responded *"No"*. Further questioning: *"If I were to tell you that the ringing is due to part of your hearing mechanism dying, would you alter your behaviour and attitudes?"* produced a response *"No"*. This attitude type was held by many.

Later in the interview, participants were asked whether education about hearing issues would alter the public's attitudes and behaviour patterns. Responses were varied. Participant 14 answered: *"Yeah, it would become a sensitive issue. It would be thought about if nothing else. I think schools are the best place. Even when kids pretend they're not listening, or taking stuff in they are. If you're taught to follow a religion from birth, you probably will. If you're taught the world is flat from birth you'll probably believe it."*

Participant 9: *"It would definitely have an effect. A proper government campaign would have an effect. Some will be persuaded, some won't. On the whole it would be good, some people don't know about the risks of hearing loss. At least they'll know the risks associated with it."*

Every participant thought that this education and advertising would alter public opinion, if only slightly.

Some 50% of non-acoustically aware - but 100% of acoustically aware - individuals mentioned hearing in response to the following question: "*What aspects of your health, if any, do you consider are at risk when attending concerts, night-clubs or gigs?*", illustrating that education in acoustics does alter the participant's thought.

In summary, the acoustically aware individuals tend to have considered noise-related issues. The non-acoustically aware individuals generally have not. In response to the question: *"Have you ever thought about potential long-term damage done to your hearing?"* 100% of aware, and 50% of non-acoustically aware, participants responded positively. The slightly different question: *"Have you ever considered your hearing, in terms of what your hearing might be like in 20 or 30 years time?"* was answered differently. A positive answer was given by 90% of acoustically aware and 20% of non-acoustically aware individuals. This suggests that 'long term' and '20-30 years' were perceived differently by some participants.

A number of acoustically aware participants have altered their views and attitudes towards noise induced hearing loss since being educated. They tend to modify their behaviour very slightly, for example acoustically aware participants stated that they *"do not stand next to loudspeakers."* Preventative measures such as earplugs are generally not used by acoustically aware or unaware individuals: 90% of acoustically aware individuals have worn earplugs in a work environment, but not in a social environment. Only 60% of non-acoustically aware individuals have worn earplugs in a work environment.

During the interview, non-acoustically aware individuals were educated to some extent. Some participants changed their attitudes slightly, some did not. All stated that their behaviour would not change.

Acoustically aware and unaware participants tend to expose themselves to the same amount of high intensity entertainment noise, the majority once a week. All participants had either shouted in someone else's ears or let someone shout into their ears inside a venue. This is something participants claim they have never done in everyday life, again suggesting that education has little effect on the behaviour of those educated. Half of both aware and unaware participants consider themselves to have good hearing.

It appears that noise exposure is very similar to smoking. Everyone knows that smoking is dangerous, and yet to many it is still a desirable activity. The acoustically aware on the whole do not wear hearing protection, and thus behave in a very similar way to the non-aware.

Earplugs

Many participants stated that earplugs were useful and good, but the vast majority did not use them: interviewee 20 said: *"They're a good idea."*

Another popular point of view held by many was (as stated by the acoustically aware interviewee 2): *"They seem really uncomfortable. It's too much hassle. Remembering to do it, getting round to getting some, you know. I think when I was younger, peer pressure has an effect. You know maybe not now, but it's kind of seen as*

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cheating." The participant raises the issue of image. Protecting your hearing is not considered as a good thing to do.

The third point of view mentioned by interviewees 16 and 4 was: *"...indifferent, I can't really see the point. If you go out somewhere to listen to the music, it seems stupid to muffle the sound."*

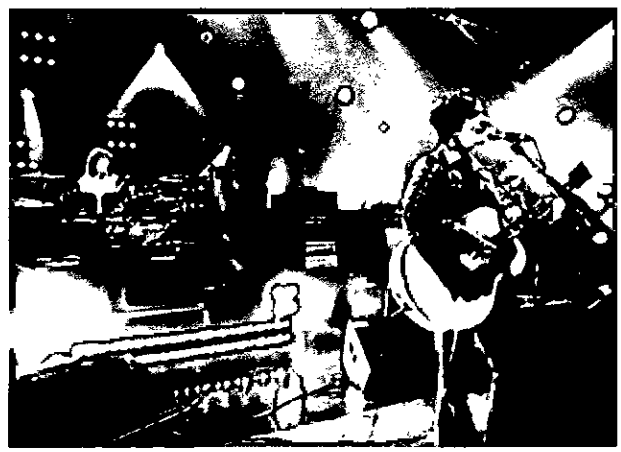
"Well, they're bad. You can't hear. There's no point in venues is there. You're there to listen."

In summary, the vast majority of participants did not wear earplugs when attending music venues, night-clubs, gigs or concerts. Many participants raised the issue that the whole purpose of going to a venue was that they were there for the music. The issue of image was also raised: in young peer groups, taking risks is often seen as better than avoiding them.

Risk

Participants were asked: *"Do you think of the health risks associated with noise exposure in the same way as the health risks associated with smoking and drinking alcohol?"*

Participant 2 gave the typical response: *"No, it's not going to kill you, whereas they do."* Participant 7 held an uncommon, different view: *"Yeah, I suppose I do, it's something I can control. So in that way they're all the same."* Participant 8 summed up the attitudes of the majority of participants, acoustically aware or not, when asked whether or not he was concerned: *"Not that much compared to the smoking risks, and whatever other risks I take."*



Stereophonics live in concert - 'if you go out somewhere to listen to the music, it seems stupid to muffle the sound' was a typical comment from interviewees

In summary, the majority of participants take risks in their daily lives. When asked: *"Do you often take risks in your life?"* 11 answered yes, 3 occasionally, and 6 no. Participants consider the other risks that they take in life as more serious than hearing related risks. They do not think about hearing, because they *"could be hit by a bus tomorrow."* They feel that there are many greater risks in life, each with large consequences when compared to that of hearing loss. Hearing loss comes a long way down on their scale of importance and is something to be worried about later in life.

Concern

All participants have had ringing in their ears as a result of entertainment based noise. Participants were then asked if this caused them concern. Acoustically aware individuals tended to be more concerned than the non-aware. Responses were different depending on the level of acoustic education of the participant. Aware individuals such as interviewee 18 said that although aware of the issues it is something that is forgotten, when having a good time, similar to damage caused by alcohol.

Acoustically and non-acoustically aware participants that were not concerned tended to say *"No"*. However, non-aware participants tended to have *"never really thought about it"*. Aware participants had considered the issue and decided due to factors such as frequency of attending venues and so on they were not at risk. Interviewee 12 stated: *"Not concerned, it reminds me that I am damaging my hearing, or that I have. I see DJs and musicians, exposed in these loud conditions everyday for 10 or 20 years, and they can still play. You need to be able to hear well to play, so if they're ok, I will be, I'm not exposed as much as that. It comes back to the life idea, everyday you take risks, I won't stop doing what I want to do because something might maybe happen."*

In summary, 100% of acoustically aware and non-acoustically aware individuals have experienced ringing in their ears. This causes 60% of acoustically aware individuals concern, but only 10% of non-acoustically aware participants are concerned. Acoustically aware participants tend to consider the issues of damage, then decide whether or not they are concerned. Acoustically unaware individuals tend not to consider the issue.

Happy?

Participants were asked if they *"...think that the general public is happy with the music levels they are exposed to in concerts/nightclubs/gigs?"* The vast majority of participants answered in this general way: *"Yeah otherwise they wouldn't go. Could make it slightly quieter, but, if people did think it was too loud, they wouldn't be there."* Interviewee 15 explained the principle of sacrifice: *"Sometimes people think it is loud. Especially in bars sometimes, where music isn't IT! For me when I'm sober I'll talk to people more. If I go to pubs before a club, I want the pubs not too loud, but I'm not as bothered about the club. So, yes most of the time, sometimes no. At a gig, some people go right to the front, to see the band, and they think it's really loud, but it is a sacrifice. You want one thing, you trade them off."*

Participant 17 suggested that the public simply do not think about the issues: *"I'd say so, I haven't really heard any complaints. I don't think about it, I don't think most people do, I haven't seen any warnings either. They do when their ears are ringing after a concert, but when that stops the thought stops. They forget about it 'til next time."*

The question produced another interesting response. Participant 19 suggested that it was what the public perceived as normal: *"Yeah, well they're used to it, it's normal. They don't know anything else."*

A similar question: *"Why do you think venues play their music so loud?"*, gave the same response in many different forms. Participant 16 gave a typical response: *"If it's loud it is more effective. People enjoy loud music, so they are providing it for people."*

The vast majority of participants, 100% of acoustically aware, 80% of non-acoustically aware, have been uncomfortable with the noise levels inside venues in the past. No participants have ever complained to staff or management about noise levels. There seems to be apathy towards the situation. Perhaps individuals feel that they are the odd one out, and so do not want to spoil the fun of others. Perhaps they do not want to complain, as this

may damage their carefree image. Perhaps it is not an issue that is important enough to them to make a point of complaining.

Mood

The vast majority of participants felt that their perception of whether a noise is loud or not, and whether they are concerned by a loud noise, is affected by their mood, and mood altering substances. This suggests that perhaps government restrictions limiting the noise levels that venues are allowed to produce, may protect the public more satisfactorily than by educating individuals, as the public will tend to behave differently depending on their mood and may take risks - for example when drunk - they would not take when sober.

Government

Every respondent felt that the government and/or local authorities have a responsibility to protect their general health. All also felt that the responsibility extended to hearing issues.

Loudness

Participants were asked: *"Why do you think venues play their music so loud?"* A number of different responses were offered. Participant 13 suggested two possible reasons for the loud music: *"People are deaf, I mean the guy with the volume switch, so they turn it up so that it sounds ok to them. The sound engineers just turn it up. That damages their hearing, and so on. They use the sound to pull people in off the street, if people hear it, they'll notice the club."* Participant 19 suggested: *"It's the idea of making people forget themselves. Forget their lives. They can really concentrate on the music. Drowning themselves in their dreams."*

Participant 14 gave the typical response: *"They think punters want it. Whether that's true or not, it must be partially right, especially for the younger generation. I think people's attitudes to noise have changed."* A five second pause yielded a further comment: *"It is different now from in the 1920s say. Now it's acceptable. If you played it to a young person in 1920, they'd hate it. Loud is a crucial part of modern music, loud wasn't a crucial part of music in the 1920s. I think the older generations just don't appreciate or like loud music like this generation does."*

When asked: *"Have you ever seen warnings about high noise levels inside venues or on tickets?"* 70% of participants stated that they had not. Whether statements are present and participants do not notice or pay attention to them, or the statements are simply not present as the venue operators have not considered the issue, is not known.

In summary, the majority of participants, acoustically aware and unaware alike, felt that the public wanted very loud music, and this was being provided. Loud music has a greater effect, and creates a more realistic suspension of disbelief. The idea of the staff in a venue being deaf, and so the music is turned up, was mentioned a number of times. Some participants felt loud music to be *'the norm'*. Many felt that if levels reduced over a period of time, no-one would complain, as they would not realise. The level must not reduce too quickly as people do not like change. This idea was thought to work: *"as long as the level was still pretty 'loud'."*

Attitudes

It became obvious that different people have different attitudes towards risk taking. Interviewee 19, who was

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raised in Switzerland, suggested that English people do think in a certain way, and that English society makes change difficult:

"It depends on how the people are educated, and how they react to that. People in England, you know, lots of them are told about hearing loss, and they are a bit concerned, but then they just forget about it. Smoking, people know, it is different, it's a kind of will power. People know that smoking is bad and you can die but, at the same time, people say they can't give up smoking. Drinking is different again. In England it's a social thing. In Switzerland it's easier to not drink, because it isn't, err, it's a different society, so it's easier to cut down. The same with nightclubs, it's less important there, the sound is less important. So it can be fixed easier. Different habits."

When asked whether education came from the government, the same participant responded: *"Yeah, at school, on TV, just generally, we're more interested in it all. At all concerts there are stalls giving out free earplugs."*

In summary, perhaps the attitudes of the public towards risk activities and noise induced hearing loss in particular are a product of the environment. The British culture may make this a larger problem here than in countries such as Switzerland.

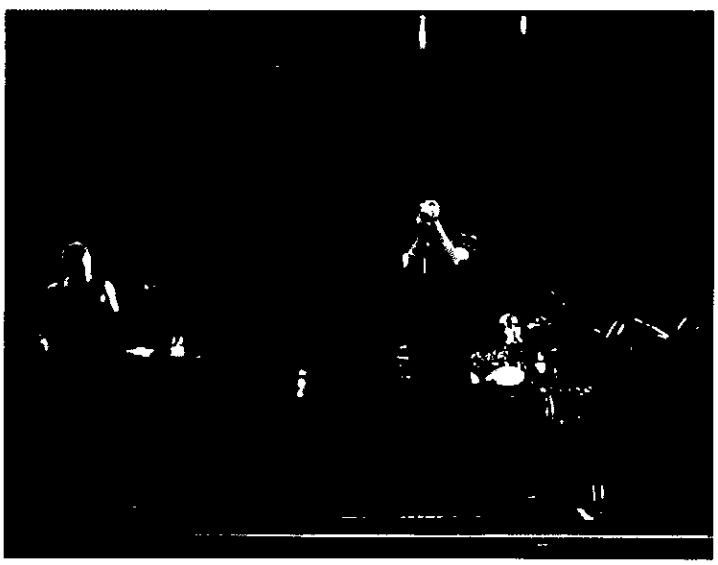
Focus groups

Three focus groups were held. One focus group was made up entirely of acoustically aware people, one entirely of unaware people, the third was a mixture. Each focus group generated masses of data, far too much to be displayed here. They raised many interesting issues. Discussions felt to be most valuable were collected into groups and are summarised below. The document is available in a more complete form which includes extracts from focus group discussions.

Loud

All three focus groups expected loud music to be played in venues. The loud music is usually not uncomfortable as they feel that their hearing is desensitised by the music. Participants wanted the music to be loud.

Participants wanted loud music at venues



Education

Participants whose attitudes and behaviour patterns had changed had witnessed the effects of noise induced hearing loss in others. The majority of non-acoustically aware participants who were partially educated during focus groups stated that education would not change their behaviour patterns.

The minority of non-aware participants said perhaps they would change their attitudes slightly. One acoustically unaware participant described ringing in his ears as being like a bruise. It went away and was not a problem. The participant assumed that no permanent damage was done, since the ringing went away.

Ringing

Ringing in the ears seems to be discussed with humour. This suggests that it is unimportant to the participants. One acoustically unaware participant said that ringing in the ears was a way of judging how good his night out had been. Although this was said with humour, there may well be an underlying truth. The view was altered as the interview proceeded and the participant gained some acoustical knowledge.

Risk

Risk associated with exposure to loud noises was not considered in any depth. Participants seemed to have a subconscious list of priorities in life, where hearing was low on the list. Many participants held the view that because you cannot die from exposure to loud noises, it was less important than other risk issues.

Knowledge

It was generally thought that the public does not consider being exposed to loud noises as a risky activity. Because noise induced hearing loss was often a long-term process, the effects were not immediate. Participants seem to only consider issues in the short-term. One acoustically aware participant stated that his ears were his livelihood, so his behaviour was not a product of his education, more a product of his need to work. However, without his education, he probably would not have considered his hearing at all.

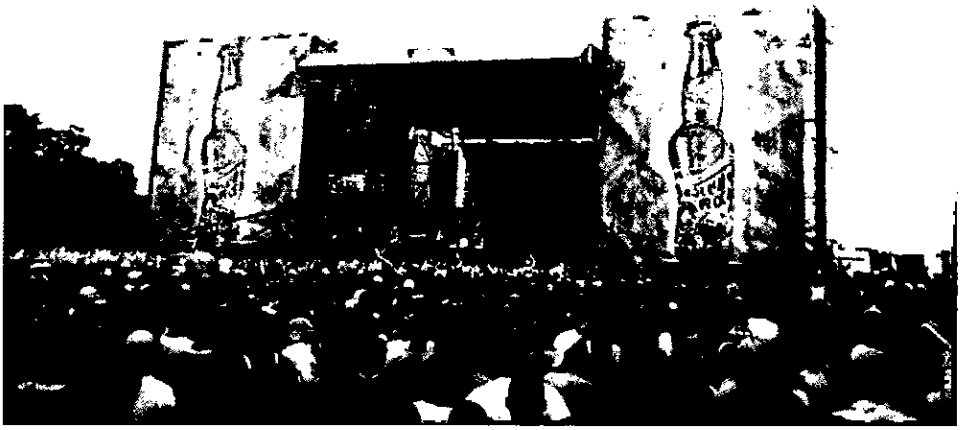
Participants seemed to be undecided about general public awareness of the dangers of high levels of noise. The participants agreed that the public was aware that loud noises were damaging, but perhaps were unaware of what 'loud' is. Unaware participants often stated that if levels in decibels were advertised it would mean nothing to them.

Complaining

Participants seem to believe that complaining to the venue operators was a waste of time. None of the participants had ever complained although the majority had been uncomfortable with noise levels inside venues at some stage.

Protection

Participants tended to assume that they were being protected by the law. Acoustically unaware participants seemed to assume that the staff in a venue had some level of relevant education. One acoustically aware participant related damaging noise levels to building sites, but not to music venues. This introduced the idea that music was not thought of in the same way as construction noise or industrial noise. Most felt that the sound in the venue was desirable, whatever the level.



It was stated many times that citizens had a right to go somewhere with loud music

Rights

It was stated many times that citizens had a right to go somewhere with loud music, just as they had a right to smoke or drink. This was thought to be an important point, and the idea that legislation may remove the right of the individual to do whatever they wished was unpopular. Fundamentally, an individual had the right to risk damaging their hearing if they liked.

Image

Participants mentioned that some people take risks to prove to their peer group that they are not weak. It seems that protecting hearing is sometimes seen as socially unacceptable. The image issue was often compared with that projected by drinking alcohol.

Behaviour

It seems that the issues may be considered or understood in the 'cold light of day'. However, when the public go out to music venues, they either forget or ignore what they have been told. Perhaps if earplugs were available and advertised in music venues, the issue of hearing loss would be raised, and the public would remember the risks that they had been told about. One participant had seriously damaged his left ear drum twice as a result of exposure to very loud music in a music venue. This shows that he did not learn from his first encounter with damaging noise.

Advertising

Advertising in the sense of publishing information about loud noise may entice more people into a venue, because the risk was seen as attractive. It was generally felt by the focus groups that even if the public did not respond to advertising by altering their behaviour, it would be better for them to know then disregard the risks than for them not know, and perhaps unwillingly take risks.

Change

Education has been identified as partial mitigation of the problem of entertainment based noise induced hearing loss. The issues surrounding noise induced hearing loss were closely comparable with those surrounding smoking. The public was aware that smoking is damaging, and some people still smoke, but it is generally less acceptable than it used to be.

Conclusions

All participants had experienced ringing in their ears as a result of entertainment noise. Acoustically-aware individuals tended to be more concerned because they understood what damage had been done. Acoustically-unaware individuals tended to view the damage as a temporary effect similar to bruising, so that once the discomfort had disappeared, the body had repaired itself. These individuals tended to have some understanding of noise induced hearing loss resulting from trauma, but not noise induced hearing loss as a chronic condition. The vast majority of participants had been uncomfortable with the noise levels inside a venue, but none had ever complained. Many participants assumed they were being protected by the venue operators or by the government, and all thought they should be protected by the government.

Earplugs were used by very few participants because they were seen as pointless. Often in young peer groups, risk-taking was preferred to risk-avoidance, so altering the attitudes of the group rather than the individual was essential.

The best way of advertising in order to alter behaviour was identified as using shock tactics, to scare people into taking notice. It was suggested that large impacts could be made on public opinion if the advertising was aimed in the right direction. Making hearing loss antisocial emerged as a popular theme.

Acoustical education tended to change attitudes to some extent, but had very little effect on the individual participant's behaviour. Those whose attitudes and behaviour patterns had changed had witnessed the effects of noise induced hearing loss in others.

In conclusion, bars, night-clubs and concert venues are full of young people every day. They go because they want to go. Many of them are taking risks they do not fully understand. Some are aware, but most of them take the same risks knowingly, as is their right. The group of acoustically-educated people who alter their behaviour is the most important, as they have considered the facts and have altered their behaviour in order to minimise the risk of them developing noise induced hearing loss. It was suggested that a policy of posting signs warning of the potential damage, and providing free hearing protection at all venues and concerts, would provide the correct balance between free choice and protection. This would allow people freedom of choice to protect themselves or not.

References

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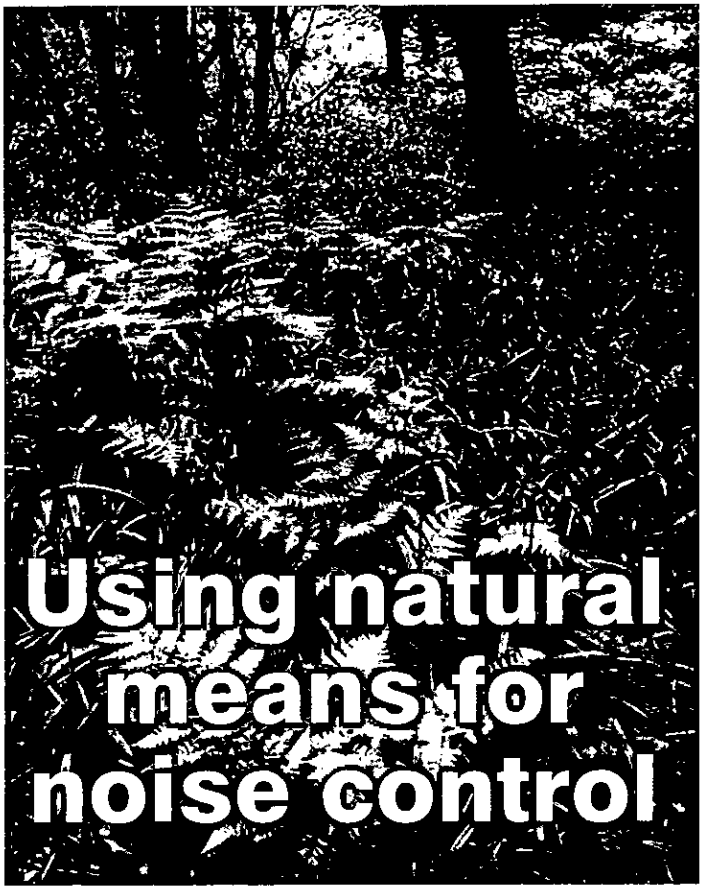
Richard Watson AMIOA *is a consultant with Hepworth Acoustics, Sheffield.*



Using natural means for noise control

Do trees reduce noise? Are there optimum configurations of tree belts for noise control? Is it a good idea for noise control to include trees and vegetation when planning cities? These questions were among those addressed at a workshop organised by **En:able**, an EPSRC funded network of ten University research groups (Engineering Network: Acoustics in the Built Environment), and held at the University of Hull . The workshop, *'Using natural means for noise control'*, presented completed and proposed research on the use of trees, vegetation and landforms for noise control in rural and urban settings. Its first aim was to build links between the researchers and the potential users of the research including highway engineers, planners, landscape architects, foresters and local authorities. The second aim was to help formulate proposals for further research.

Prof Keith Attenborough (Research Professor in Engineering at the University of Hull and member of the En: able network) gave a talk, *'Data and mechanisms for sound reduction by trees, vegetation and ground'*. He presented examples of data showing reductions between 1 and 8 dB of A-weighted road traffic noise levels as a result of belts between 10m and 100m wide. He explained that three components of natural tree belts - the decomposing vegetation layer on the ground, tree trunks and branches and foliage - all contribute differently to their acoustic performance. All of these effects depend on frequency. Because of its low flow resistivity, the interaction of sound with the typical forest floor leads to a peak in the noise reduction below about 300Hz for a source and receiver height of about 1m and a source-receiver distance of the order of 100m. This contrasts with the effect over typical open grassland that produces a peak between 500Hz and 800Hz for the same geometry. As a consequence narrow belts of trees are more likely to be effective with low frequency sound than with road traffic noise.

Tree foliage reduces sound levels through viscous friction and thermal exchanges similar to the acoustic processes inside a porous layer. The amount of reduction depends upon the total surface area and hence on the density of foliage. Prof Attenborough showed examples of data, obtained with loudspeaker sources, which could be predicted simply by adding the foliage effect to the ground effect. These data indicate that sound scattering by trunks and branches is relatively unimportant. He described ways of predicting the acoustical performance depending on the tree species, undergrowth (vegetation density) and the width and height of the belt. He pointed out how the noise-reducing effects of trees are less dependent on weather conditions than the noise reduction over open grassland since the wind and temperature gradients inside the trees are less than outside. Moreover, recent research in Belgium has shown that the presence of trees near to a noise barrier can improve the performance of barriers in windy conditions when the receiver is downwind of the source. Based on existing knowledge, he described some design rules for the use of trees and shrubs for noise control.

Prof Attenborough also explained how crops and cultivation practices, including ploughing, can help with noise control. Dense crops offer similar, but greater, high frequency attenuation to tree foliage for low sound paths. There is some evidence also that the presence of crops alters the ground effect. Ploughing the ground has been found to reduce the frequencies at which ground effect occurs. This means that ploughing might be a useful method for controlling low-frequency noise. Recent experiments have shown a useful effect at 1m high receivers between 15 and 50 m from 2m high explosions.

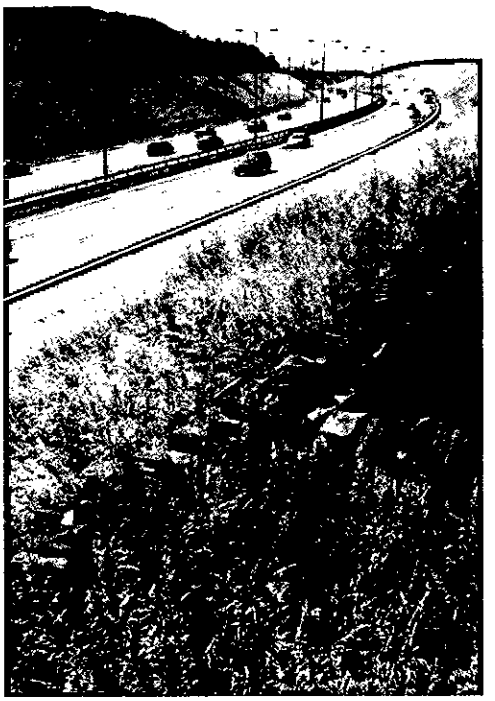
Practical and ecological concerns

In subsequent discussion, it was felt that removing the litter layer from the floors of tree belts to improve their performance against road traffic noise was neither practical nor ecologically desirable. Moreover, there were planting restrictions that prevented the suggested high foliage densities to ground level. Also, in many situations, even a 10m wide tree belt alongside a road was not possible. However, it was generally agreed combinations of barriers or landforms with trees were practicable and that, in particular, the combination of a single row of trees with a noise barrier was an interesting prospect. The importance of using native rather than exotic tree species was mentioned. It was noted that tree-planting practices often give rise to grooved ground. Moreover, ploughing in arid areas was useful ecologically. Some attendees pointed out that planting biomass for fuel was a useful adjunct to noise control.

Dr Trevor Cox (University of Salford and En:able) outlined how regular 'natural' structures might be used to enhance noise control. When objects are arranged in a periodic manner, such as the regular arrangement of trees seen in many conifer forests, then the periodicity will affect how the sound propagates through the forest. The trees form sonic crystals, and these have direct analogies to real crystals. It is known from crystallography that a periodic crystal structure prevents the transmission of sound at certain frequencies, known as band gaps. In the same way, regular arrangements of trees will prevent transmission at certain frequencies. Dr Cox discussed whether this could be exploited for noise control.

As Victor Krylov has pointed out in a recent letter to *Acoustics Bulletin*, noise problems generally exist over a broad bandwidth, and so broadband control is more

useful. The key is therefore to broaden the band gaps, or to introduce many band gaps that can span a reasonable frequency range. These frequencies need to be chosen to complement the attenuation due to ground and foliage which happen at low and high frequency respectively. Dr Cox discussed how this might be achieved and presented some example predictions. The modelling so far has been hampered by lack of values for the acoustic properties of the trees and the acoustic medium.



Dr Cox then went on to discuss how impedance matching could be used with hedging to maximise the transmission loss through shrubs. Bragg stacks are used in physics to prevent the transmission of a particular frequency in optics. They consist of a stack of two different materials, with alternating layers of the two materials. The layers are a quarter of a wavelength thick, and so this maximises the reflected energy back towards the source. A similar approach can be used in acoustics to form a 'Bragg hedge'. Alternate layers of hedging and air-space are used. Initial models used a quarter wavelength thickness for each layer, but better impedance matching may be possible for the hedge layer. Dr Cox presented results showing that this technique could provide additional attenuation at certain frequencies. Again, methods for broadening the transmission loss over a broader frequency range are needed, and the lack of acoustic data for hedging materials meant that there was considerable uncertainty about the predictions produced.

Issues include biodiversity, cost and longevity

These concepts promoted much discussion. Issues such as biodiversity, cost and the longevity of the solution were raised. For instance, these crystals would have to be designed so they would work throughout the year, and would also have to work as the trees grow. Some people favoured a mixture of both natural and man made structures in a wood to improve transmission loss. The work presented by Trevor offered some interesting avenues for future research, but it is too soon to recommend their use in noise control.

Prof David Oldham (University of Liverpool) and **Dr Jian Kang** (University of Sheffield) - both En:able members - discussed the application of trees and vegetation for noise control in the urban street canyon where the efficacy of vegetation might be greater than in the open due to multiple reflections. The effect of trees in the street canyon will be to introduce additional absorption and scattering. This effect is closely related to work on the scattering of distributions of fittings in disproportionate buildings (such as factories and underground stations). Vegetation on building façades and the ground will also increase boundary diffusion when sounds impinge on the boundaries and also increase boundary absorption.

Recent research has demonstrated that in street canyons with diffusely reflecting boundaries the sound attenuation is considerably greater than that with geometrically reflecting boundaries, typically 5dB over a relatively short propagation distance along the street. This increase in attenuation is due to increased sound energy losses from the street canyon resulting from scattering of sound out of the street channel and the reduction in the mean free path between successive encounters between sound and any absorption present. It has also been shown that even for façades where only about 20% of the energy incident upon the boundaries is diffusely reflected, the sound field in an urban street is close to that resulting from purely diffusely reflecting boundaries. This means that the effect of adding even a small amount of diffusion to a street canyon where the reflections are mainly specular can be very beneficial.

The presenters stressed the need for a better understanding of the absorption and diffusion mechanism of vegetation distributed in the street, on building façades and the street ground, and the shortage of relevant basic absorption and diffusion data. This information could be obtained using physical scale models in a semi-anechoic chamber backed up with on-site measurements. The development of predictive models based upon the concept of equivalent added facade absorption arising from this effect might then be possible. Existing computer models could then be modified to take into account the effect of vegetation in streets. With the new computer model and the basic data obtained, a parametric study for propagation in single street canyons and for interconnected streets could be carried out leading to the development of design guidelines.

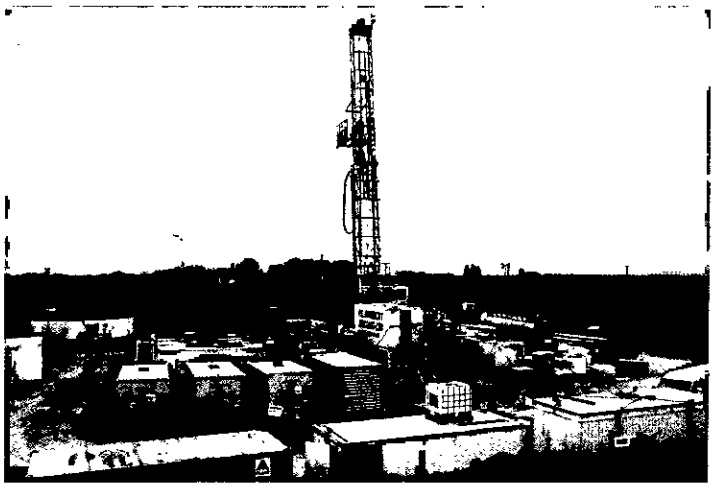
In the discussion that followed the practical problems associated with the use of vegetation were raised. Mature trees in the confined space of a street canyon introduce difficult and expensive maintenance problems. The issue of roots causing damage to underground services was a particular concern. It was suggested quite seriously that artificial trees might be developed for noise control purposes. It was pointed out that in the street context, large mature trees are probably the least efficient natural sound scatterers as their effects occur well above pedestrian level. Vegetation in the form of dense shrubs in planters might be very much more efficient at scattering the sound out of the street channel without the problems associated with large mature trees.

Prof Attenborough, Dr Cox and Prof Oldham proceeded to discuss their ideas for further research. Keith Attenborough described the needs for more data and modelling of the various effects. Trevor Cox reiterated the need for acoustic data on tree and hedge materials from which more realistic predictions of sonic crystal effects can be made. David Oldham outlined a programme for additional measurements and scale model experiments. In the resulting discussion several attendees volunteered sites and letters of support for further research work.

For further information on En:able, please visit our website www.acoustics.org.uk or e-mail the co-ordinator, **Dr Sophie Maluski**, at S.Maluski@salford.ac.uk.

En:able

Engineering Network: Acoustics in the Built Environment



New guidelines for environmental noise management

Work and Workshops in progress

The British Standards Committee responsible for developing standards to measure and assess residential and industrial noise is designated committee EH1/3. This committee is responsible for BS 4142 *'Method for rating industrial noise affecting mixed residential and industrial areas'* and related standards, and for collating UK responses to consultation on international standards in the same general area. The current version of BS 4142, published in 1997, is applied to a very wide range of applications, not all of which lie directly within the stated scope of the standard. The assessment methodology has also been criticised on numerous occasions.

Following various reviews of BS 4142, such as the NPL work (N D Porter, Study of the application of BS 4142: 1990 'Method of rating industrial noise affecting mixed residential and industrial areas', NPL report RSA(Ext) 0057A, June 1995, and three very well attended workshops organised by the Institute of Acoustics (Basingstoke 2001, Glasgow 2001, Salford 2002), committee EH1/3 decided to commission new guidelines for environmental noise management which would clarify the application of existing standards and regulations within the different areas in which environmental noise management normally takes place. It should be noted that this is to be to be a new British Standard intended to complement existing standards and guidance.

In June 2003, the committee appointed a team led by Ken Collins and consisting of Ian Flindell, Nicole Porter, Nigel Cogger and Colin English, to prepare a draft of the new guidelines for public consultation. The proposed work plan will enable the team to develop the guidelines through a series of drafts that respond to user feedback. The EH1/3 committee will then undertake the actions required to take it forward as a British Standard.

The team is currently working on the initial draft. IOA members will be encouraged to comment on this document, which will be downloadable from the RPS and English Cogger Partnership web sites (www.rps.co.uk and www.tecp.co.uk) by the end of October 2003. In order to facilitate feedback the IOA will be holding half-day workshop sessions to discuss the draft. These are scheduled to take place on Wednesday 12 November at the City Conference Centre, London; Wednesday 19 November at the Manchester Thistle Hotel; and Wednesday 3 December at the Edinburgh Thistle Hotel. As well as feedback from the meetings, written comments following the workshop sessions, or indeed comments from any member who is unable to attend a workshop, will be most welcome. These should be sent to Ken Collins at RPS so that the team can take them into account when preparing subsequent drafts.

This article gives some background information to the work, explains the need for a new approach, sets out EH1/3's requirements for this guidance and briefly introduces the concept of a framework for effective environmental noise management upon which the guidance will be based.

The need for a new approach

Most readers will be aware that while noise assessment is only a part of the overall process of environmental noise management, the general focus of most existing standards and regulations is on assessment and not management. For example, the main outcome after following the procedures set out in BS.4142:1997 is an assessment of whether or not complaints are likely. The standard does not offer any recommendation about what to do if complaints actually occur. If the standard predicts that complaints are unlikely, then any resident who does complain is unlikely to feel that his or her position has been properly represented. If the standard predicts that complaints are likely, but there are none, it may not be necessary to take any action at all even though a strict interpretation of the rationale behind the standard would have implied that noise control action of some kind would have been justified.

In addition, there are a number of different methods, either proposed or in use, any of which may be more or less applicable in any given situation and which often provide conflicting or otherwise incompatible results. There is widespread confusion about the precise aims and objectives of the different noise assessment methods, and this can often lead to unnecessary disagreement. This points to a need for a general and practical approach to environmental noise management based on noise assessment in real situations. Furthermore, it is unlikely that any single noise assessment procedure could be developed which would always lead to the best compromise noise management solutions under all possible circumstances. For this reason, the guidelines for environmental noise management will be based on a framework showing the different applications of existing procedures inherent in the various standards, within the contexts in which they arise.

EH1/3's requirements for the Guidelines

Committee EH1/3 has taken the view that the guidelines should not be prescriptive, in the sense of recommending only one type of approach, but that they should instead encourage the selection of the most appropriate methods depending on the context in which the noise problem occurs, based on the concept of *informed flexibility*. It is important to define noise problems in terms of the

alternative noise management solutions available in any particular case, and then to select the methods of assessment which enable comparisons between the alternative solutions.

Committee EH1/3 expects that it will be possible in this way to

a) provide clear guidance as to which existing standards and regulations appear to be the most appropriate for application in any particular situation, without being overly prescriptive; and

b) provide guidance where conflict exists between two or more standards and regulations which both appear to be equally applicable, as to the best way to present the available information so that decision makers can select the most appropriate solutions.

Committee EH1/3 intends that the new guidelines should

a) significantly ease the task for decision makers in any matters where there has been a dispute, by more clearly setting out the relative advantages and disadvantages of alternative approaches to appraisal and assessment. This should also enable practitioners to ensure that all relevant matters have been covered in any submissions, or to discover any omissions made by other parties to a dispute; and

b) facilitate savings in effort and resources and enable better solutions to be adopted.

Over the longer term, the new guidelines should

a) assist in pinpointing where existing standards may conflict or may be redundant, where new specific standards may be required, and where new research may be necessary. However the guidelines are not intended to be a critique of existing standards;

b) support further UK efforts to ensure that the actual costs to industry and the public are properly met when discussing future applications of academic research in this area; and

c) assist in reinforcing UK industry best practice in the context of the introduction of ISO or CEN standards which the committee consider may not be in the UK's best interest.

Initial framework for effective environmental noise management

Currently the selection of standard methods for use in environmental noise assessment and management is usually dependent on type of noise source or in some cases type of noise effect. For example, the introduction of road traffic noise to an area of existing housing is usually assessed by reference to the *Design Manual for Roads and Bridges*, whereas in the case of the introduction of new housing adjacent to existing road traffic noise, local authorities are encouraged to consider the approach in PPG24 . The approaches in the two documents are inconsistent.

This work is to be based on a different model, the steps of which are depicted in *Figure 1* and explained briefly below.

Step 1: Define noise problem

Environmental noise problems can occur in a number of different ways. First, the type of problem must be identified and then defined within the context in which it occurs. It is not simply a case of determining the source, or effect, in

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New guidelines for environmental noise management

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order to decide how best to address the assessment and management, but to consider what type of noise problem it constitutes.

❑ Problems can arise as a result of the introduction of a noise generating development, such as new transport infrastructure or new industry, from the introduction of new noise-sensitive development in an existing noisy area, from existing residents exposed to existing noise who have suddenly decided to complain, or new residents exposed to an existing noise source.

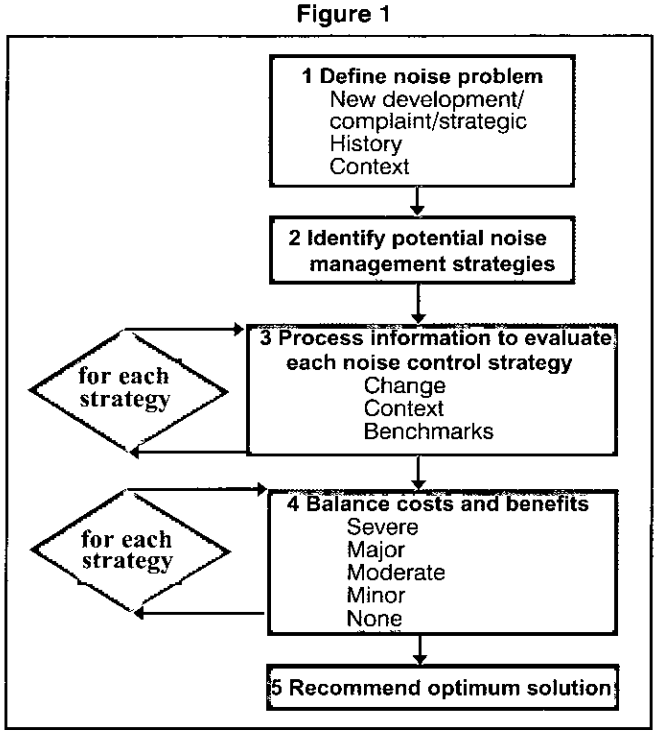
❑ A noise problem may be identified as a result of complaints. However, complaints are not always a reliable indicator of the scale and magnitude of a problem, while an absence of complaints does not necessarily indicate that there are no problems. In cases where BS.4142 indicates that complaints are likely, there is no guidance on appropriate solutions.

❑ Strategic assessments are now in the forefront of long-term planning policies as a result of the new European Directive on the assessment and management of environmental noise, and may be required on a national or regional basis. Policies derived from such assessments need to be based on a consistent rationale and to be designed to deliver a significant and cost-effective result.

Step 2: Define potential noise management strategies

All possible or feasible noise management strategies should be identified and then evaluated to determine the most practical and cost-effective solutions. Strategies may range from taking no action, to complete removal or shut-down of the noise source, with (usually) a wide range of possibilities in between. Assessment procedures should enable discrimination between alternative strategies, taking into account all such aspects as community response and context, as well as the noise levels themselves. In cases where there is no possible or feasible action that can be taken, then there is no point in carrying out any noise assessment.

Figure 1



Step 3: Process information

All available information should be assessed following procedures that maximise consistency in decision making. This usually requires some form of numeric comparison whereby numbers are assigned to actual noise levels according to a standardised scheme of measurement, and those numbers are then compared in one of three generic ways (change, context, or benchmarks) to derive an outcome or result from the assessment.

Consideration may need to be given to

❑ the likely *change* in noise levels before and after noise control action or development;

❑ the soundscape or *context* of the affected area (new noise may be less significant in high background noise level areas, or a small increase in noise levels or a change in the character of the noise might be more significant in an otherwise quiet or low background noise area); and

❑ the extent to which noise levels approach or exceed established *benchmarks* defined in existing guidelines or criteria, or separately agreed and justified for a particular assessment.

Step 4: Balance costs and benefits

It is always desirable to balance the economic costs of noise management against the socio-economic costs and benefits arising from the noise itself, or from any reductions in noise achieved by the adopted management strategy. The significance criteria may have to take into account such aspects as the importance of the scheme giving rise to the noise problem and the number of people affected, as well as the extent to which each individual is affected. Other environmental costs and benefits may also be relevant to the assessment of the scheme as a whole.

Step 5: Recommend optimum solution

The underlying basis of the assessment procedure is as relevant to the final recommendations as the results, or the outcome of that procedure. It is important to avoid an over-rigid approach where standard solutions are applied automatically, regardless of whether there are any better solutions available. At the same time it is also important to avoid being so flexible that inconsistency results. The final recommendations should, therefore, be supported by written justifications wherever a standard procedure has either been departed from or amended.

The work will be based on this framework, with consideration for the level of prescription which can be given to any stage. In this way, the new guidance can meet the requirements of EH 1/3 including the need to distinguish between the various assessment methods.

The drafting team

Ken Collins is a director of RPS Planning, Transport and Environment with over 30 years experience in environmental noise management. **Dr Ian Flindell** is widely known across Europe as an independent consultant and also teaches and researches part-time at the Institute of Sound and Vibration Research at the University of Southampton. **Nicole Porter** is also an independent consultant, having worked in a number of different sectors of the industry including various consultancies, the National Physical Laboratory and the Civil Aviation Authority. **Colin English** and **Dr Nigel Cogger** established The English Cogger Partnership in Winchester in 2000, each having 30 years of experience in acoustics, mainly in consultancy.

Photo couresy of Simon J L Blumlein

Alan Dower Blumlein

(1903-1942)

Stereo sound
High definition television
Centimetric radar

John Tyler FIOA

In mid afternoon on Sunday 7 June 1942, a beautiful summer's day with clear skies, a perfect day for flying, a Halifax bomber crashed on fire into the hillside of a valley just north of the River Wye in the parish of Welsh Bicknor in Herefordshire. All eleven aboard were killed. Of the three EMI scientific personnel who died that day, Alan Dower Blumlein was possibly the greatest loss. The purpose of the flight had been to test a prototype H2S airborne centimetric radar equipment which utilised the newly invented, and highly secret, resonant cavity magnetron, the circuitry for which was almost entirely designed by Alan Blumlein.
'A national tragedy' one of his colleagues would call it, for at a time when scientific genius was at a premium, Blumlein was without any doubt one of the most brilliant engineers of the twentieth century. He was 38 years old.

Background

This article describes the life and achievements of a brilliant mind, the impact of whose efforts in the development of radar not only contributed greatly to the successful outcome of the Second World War, but who had, before the war, developed for EMI a successful all-electronic television system in competition with Baird (in use in the UK until 1986). His pioneering work on binaural sound and stereo recording and playback in the 1930s provided the basis for the post-war realisation of multi-channel sound.

Although he wrote only two learned society papers in the course of his short professional life, he wrote or co-wrote a total of 128 patents ranging over the fields of telephony, electrical measurements, monophonic and stereophonic sound recording and reproduction, high definition television, electronics generally, antennas, cables and radar. After his death, Isaac (later Sir Isaac) Shoenberg, who was Director of Research at EMI Ltd where Blumlein had been employed from 1931, said: "There was not a single subject to which he turned his mind that he did not enrich extensively".

As a result of the cloak of secrecy which surrounded the accident - due to the sensitive nature of the work, both at the time and for decades since the war - little has been published about Alan Blumlein's achievements.

Thus, from the outset I would like to acknowledge my indebtedness to the information in the two recent excellent and complementary biographies of Alan Blumlein. These are:
The Inventor of Stereo: The Life and Works of Alan Dower Blumlein, by Robert Charles Alexander (Focal Press, 1999, ISBN 0 240 5162 81); and
The Life and Times of A D Blumlein, by Russell Burns (IEE History of Technology Series 24, The Institution of Electrical Engineers, 2000, ISBN 0 85296 773 X).

The more I studied these books, the greater the admiration I have for the authors who spent several years researching the subject in depth including interviewing those people, then still alive, who worked with Alan. I would recommend that readers who would like to know more about the subject acquire one or both of these remarkable books. Robert Alexander also maintains a useful website which contains details of some of the most important of Blumlein's patents as well as much interesting additional information.

I would like to thank the staff of the Archive Division of EMI Ltd (**Ruth Edge, Kate Calloway** and **Garry Pietronave**) for the discussions I had with them, and for permission to use their historic photographs of the early equipment.

I have also had considerable help from **Simon J L Blumlein**, Alan's elder son, who was six at the time of his father's death. He had cooperated closely with the authors of the two biographies, and provided me with photographs and useful background information.

To provide an interesting link with this history and that of Berliner *(Acoustics Bulletin May/June 2003)* it is interesting to note that Alfred Clark, who had formed the Berliner Company with Berliner to produce seven-inch shellac discs, came to England from America in 1899 to help establish the English Gramophone Company (HMV) and subsequently became the first Chairman of the newly formed Electrical and Musical Industries Ltd (EMI) in 1932.

Early years

Alan Dower Blumlein was born on 29 June 1903 at 31 Netherhall Gardens, Hampstead in London, a relatively affluent part of the borough. In 1912 Sir Edward Elgar moved into number 42 Netherhall Gardens: though interesting, it is of no relevance to this account as the Blumleins had moved to South Africa by then!

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Alan Dower Blumlein

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Alan was the only son of Semmy Joseph Blumlein, a financial merchant, and Jessie Edward Blumlein (nee Dower). Semmy was born in Offenbach, Germany but in 1877, when he was 14, had been sent by his father to Liverpool in the care of an old family friend. This was because his father detested the German military system and did not want his son to be conscripted into Germany's National Service. This explains Alan Blumlein's German surname. Semmy Blumlein became a naturalised British citizen in 1905 when he was working in South Africa; Alan and his mother went out to Johannesburg in 1906, when Alan was three years old.

Problems with the company meant that the whole Blumlein family returned to England in 1907 and Alan began school the following year. Because of the relative wealth he was born into, Alan had a nurse (nanny), Dudu, to look after him and provide his initial education. As she read to him regularly, and he possessed a remarkable memory for what he heard, he was slow to develop his reading skills. Until he was about 11 or 12 years old he could read very little and had no feel for spelling. This latter shortcoming stayed with him for the rest of his life. Alan was twelve when his father died very suddenly and he realised that if he was to make progress in the world he needed to improve his reading and writing ability. His mother sent him to a 'cramming' school in Brighton. Such was his innate ability that within two years he had learned to read and write well enough to win two scholarships – to Aldenham and Highgate grammar schools.

Much later in life Alan's wife Doreen recalled that in conversation with her husband she remarked: "You couldn't read properly until you were 12, could you?" to which he replied "No, but I knew a hell of a lot of quadratic equations!". As Doreen remarked, he knew what he wanted to know, and the rest he didn't bother with.

In view of Alan's aptitude in science his mother Jessie chose Highgate grammar school because of its good reputation in science subjects. He joined as a boarder in 1918.

Higher education

Alan did well at Highgate and in 1921 was admitted to the electrical engineering degree course at City and Guilds College which was part of Imperial College of Science and Technology, a school of London University. His education at Highgate had been so good that he passed the examinations which allowed him to enter directly into the second year of the degree course and he was awarded one of only six Governor's Scholarships, worth £60 per annum. The records show that Blumlein held his scholarship for the two years he was an undergraduate student.

On completion of his course Blumlein was awarded the City and Guilds Institute diploma and additionally sat the examinations required for the University of London's BSc(Eng), achieving first class honours at the age of 20. His examination subjects were electrical technology, electrical machine design, electrical generation, distribution and utilisation.

One of his fellow students, a J M Turnbull, who later worked with Blumlein at both Columbia Graphophone Company and Electrical and Musical Industries(EMI) Ltd, remembered him as being quite popular and 'mixing pretty well', although he apparently did not suffer fools gladly. Although not participating in team sports, Blumlein was a very good swimmer and represented Imperial College in such events, for which he received the college's colours.

Considering the excellent academic progress, the scholarships, and the award of a first class honours degree after only two years of study, the impression may have been given that Blumlein's life had been one unremitting regime of study and hard work with no time for leisure pursuits. Yet, he was not a dull unsociable swot with little interest in the light-hearted. The speed at which he could assimilate knowledge allowed him time to enjoy some of the pleasures of student life. John W May has written: 'He was one of my greatest friends from his arrival at Fitzroy Lodge (Highgate School) until just before the war when we lost touch. Throughout the 1920's we were always out together. I can remember him as a terrific practical joker and a great fun lover - Chelsea Arts Club Balls, weekends together in Paris, bridge, parties, anything that was going ... what I chiefly remember is a lot of fun together.'

The first job

After graduation Blumlein had to decide whether to pursue postgraduate research for a higher degree, enrol on one of the department's postgraduate courses, or seek paid employment. A major consideration at this stage in his life was the need for some income. From 1914, following the death of his father, he had been supported by his mother and two scholarships, but now he probably felt that the time had arrived for him to seek paid employment. By good luck two posts for assistant demonstrators were available in the department and Blumlein decided to apply for one of them. He was successful and was soon assisting Professor Mallet with his special advanced lecture course on *Wireless telegraphy and telephony.*

E A Nind was one of the students helped by Blumlein and his recollection was of a 'delightful man, very human indeed,

who had a good sense of humour and was very good at explaining anything. He did not get exasperated if you did not understand and would go through a point again and again. He had inexhaustible patience and had a great facility for converting quite complicated mathematics into very simple circuit elements'. When Nind left college in 1926 he too, like Turnbull, went to the Columbia Graphophone Company, and once more experienced Blumlein's outstanding ability.

Blumlein spent one year researching, under Professor Mallett's supervision, a new method of measuring high frequency resistance. The work led to a paper submitted in 1924 to the Institute of Electrical Engineers for possible publication in the journal of the Institution. The referees' report to the IEE said: 'The paper appears to have been hurriedly put together; the authors should be asked to go carefully through it, to rectify errors and *improve the English'* (my italics). This was done and the paper was read in January 1925 to the Wireless Section of the IEE. Later Blumlein and Mallett were awarded one of the IEE's premiums for their work; Blumlein was just 21 years old, exceptionally young for such a presentation.

The second job

In 1924 Blumlein moved on from academic life to join the International Western Electric (IWE) Company as a telephone engineer in the transmission department. The company was a division of Bell Laboratories of America, soon to become International Standard Electric Corporation and later still Standard Telephones and Cables. At IWE he worked with J B Kaye, who became his closest friend; he was best man at Alan's wedding in 1933 and became godfather to his son Simon who was born in 1936.

Both received good training and experience in various aspects of telephone engineering and Blumlein's first encounters with acoustics came through the evaluation of a capacitance microphone invented by Wente in 1917 at the Bell Telephone Laboratories in the USA, and the testing of an early audiometer which had been sent over by the Bell Laboratories. The latter was developed by Blumlein to include an electrical network to enable the instrument to produce an output, for a given sound input, corresponding to the response of an average human ear. This may well be the first ever use of weighting.

In February 1925 Blumlein was transferred from his post in the transmission department and joined Dr John Collard's group, which was concerned with interference, cross-talk and acceptance tests on the long distance inter-city telephone lines then increasingly being installed in continental Europe. From 1925 to 1928 Blumlein spent much time in Europe, involved in the investigation and prediction of noise interference in telephone lines caused by power lines and the overhead conductors of electric railways. In some countries, particularly Switzerland, the telephone cables were laid alongside or were parallel to the power lines.

Some of the work done at this time formed the subject of the first patent that Blumlein filed with a colleague, John Percy Johns. They conceived the idea for a method for reducing mutual interference between channels (cross-talk) in long distance telephone cable systems - they were certain that much of the interference produced was a direct result of the three-coil inductively loaded cables being used at the time. Blumlein invented a measuring set to meet the conditions the test engineers would encounter in the field, which consisted of an AC capacitance bridge in which the ratio arms were the windings of a mutual inductor. The method worked so well that it was used, in various improved versions, until very recently, only being replaced as a result of the introduction of digital/optical telephone systems. He took out seven patents while with STC concerning telegraphy and telephony, both overland and undersea.

The ISEC was so pleased with the work done by Blumlein and Johns, which had not only greatly improved the quality of the telephone systems they were installing all over Europe, but had cut down the time spent by engineers testing for interference in the field by a large amount thus saving the company vast sums of money, that they were awarded a bonus of £250 each. This was virtually a year's wages at the time and Alan spent his on his first car, a bullnose Morris! His driving became legendary in the years that followed. He would think nothing of explaining a complicated engineering problem to whoever was in the car with him by drawing it on the windscreen, as he was driving!

This naturally led to Blumlein's increasing interest in flying, which culminated in early 1928 in flying lessons at the London Aero Club near Hendon, given by the instructor who had taught Amy Johnson. He made such rapid progress that he obtained a pilot's licence by October of that year.

Sound recording and reproduction

Single channel — mono

In 1929 Blumlein probably felt the need for a new challenge and so responded to an approach from Isaac Shoenberg, general manager of the Columbia Graphophone Company (later to merge with HMV to form EMI at Hayes in 1931). The situation at the time was that both Columbia and HMV had to pay royalties to Western Electric (Bell Telephone Laboratories) in the USA to use their superior recording process (the story of how this came about is fascinating in itself: readers wishing to know more should read one of the two biographies already mentioned). As both UK companies were pressing about two million records every month, by the end of the 1920s, royalty payments were considerable (between 0.875d and 1.25d per record) and they were looking for ways of getting round the Western Electric patents.

Isaac Shoenberg had, by the beginning of 1929, come to the view that Columbia's recording developments were not sufficiently successful, and looked around for a first class engineer to work on a new system that would be free from Western Electric patents. Columbia also needed to design a high frequency, high quality microphone. As soon as he joined the company Blumlein was given both these tasks.

The Western Electric recording cutter was a moving iron type having certain inherent disadvantages from the point of view of linearity. It also used mechanical damping of resonances. This was the type which Columbia engineers had been working on before Blumlein arrived. Blumlein based his new design on moving coil principles and electromagnetic,

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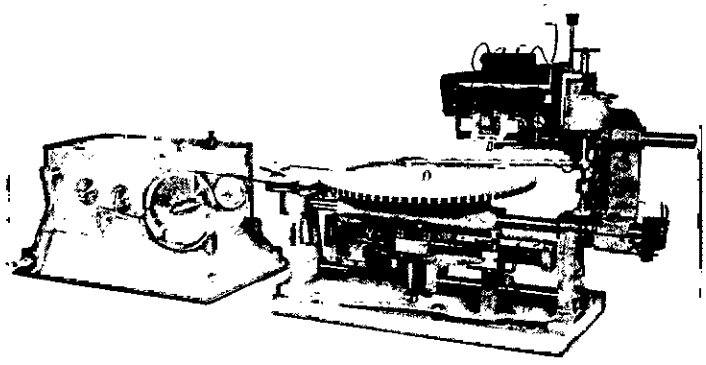

1928 Columbia gravity-driven wax cutting lathe with 1932 production model Blumlein moving coil wax cutter
Source: EMI Archives

Alan Dower Blumlein

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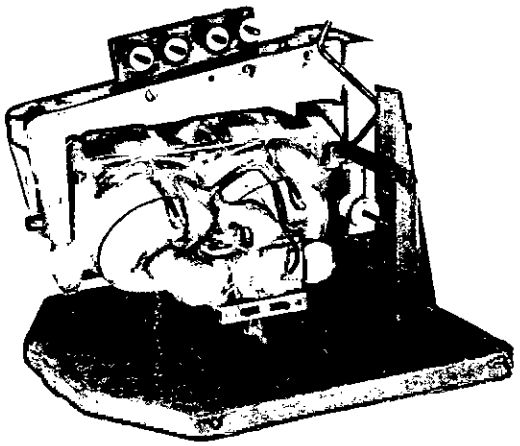
as opposed to mechanical, damping. He had become aware - as had others before him - of the potential of moving coils. Only a few years earlier in 1925, Rice and Kellogg had produced the world's first moving coil loudspeaker and so the principles were not new; in fact Blumlein was surprised that no one had thought of using moving coil recording cutters before. The prototype moving coil cutter developed by Blumlein and his colleague H E Holman, who produced the mechanical design, is shown in the figure below; the design was patented in 1931. The system not only overcame the Bell (Western Electric) patents but also produced better recordings.

To complete the new recording system, Blumlein required a new high quality microphone, one of the reasons he was employed by Shoenberg. As the main object of the whole exercise was to avoid paying royalties, the Western Electric capacitor microphones could not be used and it was necessary for Blumlein to design a microphone which embodied some novel and patentable features.

By the time Blumlein started to devise his design, much work had already been done by other researchers on carbon, capacitor, crystal and moving coil microphones. In particular, Western Electric, whose patents the Columbia Graphophone Company wished to avoid, had experimentally investigated all four types of sound transducer.

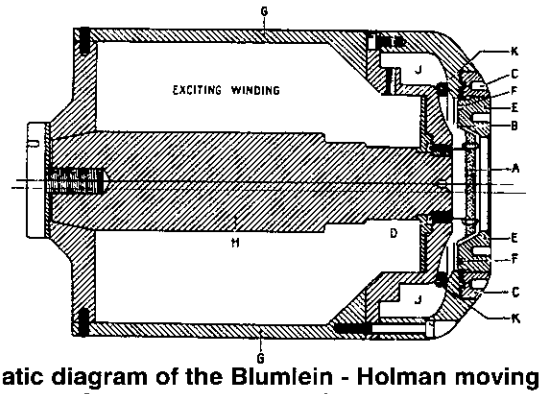


Developmental model of the Blumlein moving coil wax cutter, 1931 *Source: EMI Archives*

In the event Blumlein based his design on the moving coil principle in which the compliantly mounted diaphragm–coil assembly, the coil of which moves in a uniform magnetic field, generates an electromotive force in the coil which is proportional to the velocity of the assembly. His diaphragm consisted of two circular aluminium sheets separated by a disc of thin balsa wood, the whole being riveted and waxed together. After numerous developments of the design and much testing, including the equaliser circuits, the prototype microphone designated HB1B (H for Holman, B for Blumlein), and the new recorder, including a new amplifier design, were ready for the first tests which were carried out on Monday 8 December 1930.

Recordings were made of a dance band and vocals: no notes exist on the results but a frequency run dated 19 December showed a very good, smooth and even characteristic. Much more development took place, including a degree of treble emphasis and bass attenuation to improve the balance. After this the HB1B microphones were used for many years, both in EMI's recording studios and by the BBC for television broadcasts from Alexandra Palace. A later model HB1E had a frequency response which extended from 40Hz to above 17kHz and was in use by EMI until at least 1955.

Blumlein's achievements, with his collaborators Clark and Holman, were remarkable, indeed outstanding. A young engineer, not yet 30 years old, with no prior experience of sound recording or reproduction, solved in just one year the

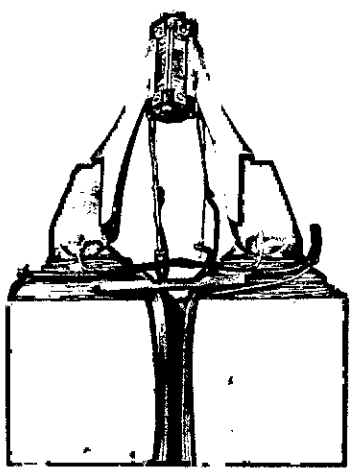


Schematic diagram of the Blumlein - Holman moving coil microphone *Source: Engineering Science and Education Journal, 2, (3), 1993*

problem which previously had involved the research staff at both the Columbia Graphophone and the Gramophone Companies. Naturally the directors of the Columbia Graphophone Company were delighted with Blumlein's work and awarded him a bonus of £200, a considerable sum for the depressed times in which it was made.(In 1931 the average weekly wage for a skilled male worker was £5.) They also awarded Holman and Clark bonuses in recognition of their important roles in the recording project.

Two channel binaural (stereo) sound

The earliest patent on stereophonic reproduction, *Improvements of a telephone equipment in theatres,* was filed in 1881 by a French engineer, C Ader. His system consisted of two telephone mouthpieces on the stage, one on the left, the other on the right. The subscriber at home had two headphones, one for each channel. The system was tried out during the Paris Exposition of 1881 on the stage of the Paris Opera, when sound signals were transmitted to the homes of subscribers. The sound quality was so poor that the idea was dropped and the concept of stereophony receded into the background.

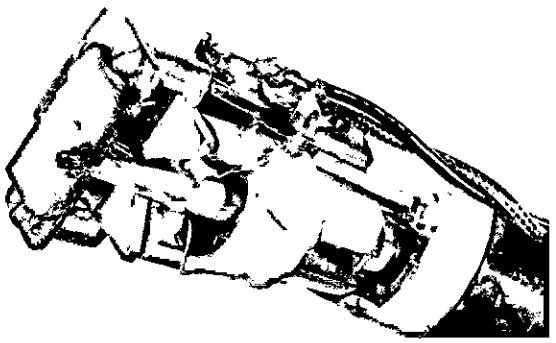


The Blumlein stereo microphone, 1934 *Source: EMI Archives*

Despite a brief revival during the First World War, when it was used to assist observers to locate the sound of gunfire and aircraft, it was not until the early 1930s that the principles of stereophonic sound recording and reproduction

were examined. Both Alan Blumlein of EMI and A Keller of Bell Telephone Laboratories filed patents in 1933/34 but their methods were quite different. Keller used three spaced microphones and loudspeakers which gave good results for public performances but were uneconomical for domestic use. When using only two microphones and speakers placed 10 feet apart there was a pronounced 'hole in the middle' effect.

Blumlein, in typical manner, considered the local conditions at an observer's ears. He believed that the main factors used by the ear-brain system in determining the direction of a sound source were the intensity and phase differences in the sounds the observer hears. In progressing



The Blumlein-Holman moving coil stereo pick-up 1933
Source: EMI Archives

his ideas on binaural hearing he developed the idea of 'shuffling', a method of modifying the microphone outputs to convert phase differences to intensity differences. Blumlein's shuffling, in a developed form, is in common use today.

It was during this period, on 1 November 1931, that Blumlein and his research and development colleagues moved from the Columbia Laboratories to the recently built (1928) research building of EMI Ltd at Hayes. Six weeks later, on 14 December 1931, the provisional specification of Blumlein's famous British patent covering the principles of stereophonic sound recording was filed (no.394 325). It is generally regarded as one of the great patents of recording literature.

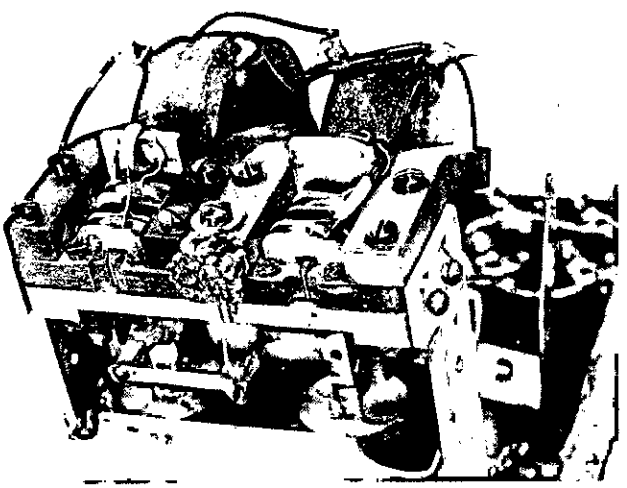
Such was the extent of Blumlein's ideas that the 24 page patent document contains 70 claims. He considered the use of both pressure type and velocity type microphones, the recording of stereophonic signals on cine film, the means for recording such signals on a single groove cut on a gramophone record (hill-and-dale and lateral, later 45/45 degree cut), the use of cellulose acetate material rather than wax for recording purposes, the design of various types of stereophonic pickup and even the idea of stereophonic radio broadcasting. All this was in 1931, decades before it all became a commercial reality.

In 1931 Blumlein's boss, Shoenberg, was not particularly eager for research effort to be allocated to binaural recording and reproduction in view of EMI's commitments in the mono recording field. The pressing and sale of records was producing income for the company, and in addition they were becoming more involved with the development of television in association with the BBC. Thus it was not until 1933 that the initial experiments on binaural recording took place. These were comprehensive and included sound on disc and sound on film, which was the concept that had initially fired Blumlein's imagination. By that time he had recruited additional staff to help with the work.

Practical testing of Blumlein's binaural ideas started in mid-1933 in the main drawing office and auditorium which had been built in 1928 by the then Gramophone Company. These tests consisted mostly of people walking and talking as they moved about relative to the microphones. The listeners were situated in a separate room containing two 12-inch loudspeakers mounted on large balsa wood baffles. Several 10-inch wax masters were cut using a stereo wax cutter based on two modified Western Electric moving-iron armature units coupled to a single stylus by a lightweight lever arrangement to allow the stylus to move both vertically and horizontally.

In 1934 several recordings of music were made in EMI's Abbey Road studios, first with a dance band, then with pianos. On 19 January the now-famous recordings were cut with Sir Thomas Beecham and the London Philharmonic Orchestra playing Mozart's *Symphony 41 (Jupiter)*. The recordings were made with the vertical modulation in the groove containing the difference information, and the lateral movement the sum information. M Gray wrote in the *TA S Journal* (23 September 1991) that: 'heard today, these pioneering recordings still sound surprisingly solid and musical, even though Blumlein's omni-directional EMI HB1B microphones spaced 20cm apart could not produce the strong directional effects that bi-polar designs were to make possible, ideas which Blumlein himself had predicted in his patent and which he developed in later experiments'.

The next phase of the tests involved recording binaural sound tracks onto a film. Subjects used included the EMI fire engine driving from side to side whilst ringing its bell; and a theatre scene staged in EMI's studio, in which a couple were dining in a restaurant too close to an orchestra to hear themselves speak. On complaining to a waiter the orchestra was moved to the other side of the room, electronically!



The Blumlein stereo wax cutter, 1933, before restoration
Source: EMI Archives

A film of steam trains leaving Hayes railway station is particularly well known and came about as a result of Alan Blumlein's lifelong fascination with railways. These films and others are held in the EMI archives.

The work on stereophony was stopped in 1935 and remained dormant until 1953. Shoenberg could see that the prospects were bleak, both for stereo records and stereo sound in cinemas. The records pressed on shellac were too noisy to be acceptable, although Blumlein did experiment briefly with other materials but with little success in the time available. There was not sufficient support from the film companies to warrant a substantial investment in the cinema sound systems. However, the principal reason for the decision was that EMI engineers and scientists were deeply involved in the evolution of high-resolution television systems.

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EMI and high definition television

Blumlein had become involved with television soon after the formation of EMI in 1931. The HMV research team, which had already started work on an all-electronic system following the first regular television transmissions in 1929 by the BBC (half an hour a day) using Baird's mechanical system, joined forces with the EMI researchers and were supported by many additions to the staff. From about March 1933 Alan Blumlein spent most of his time on television work; from this date he effectively became project leader until the BBC adopted the EMI 405 line system in 1936, when it opened the London television station.

In this incredibly short time the EMI R&D staff had to engineer, virtually from scratch, all the necessary electronic equipment: amplifiers (head, video, radio frequency and power), modulators, pulse generators, pulse forming circuits, equalisers, filters, attenuators and special power supplies. In this work Blumlein played not only a leading role - he had a manner in working with people which got the best out of them - but designed many of the circuits which were used. Although many British patents were taken out by several members of the research staff, Blumlein himself was responsible for no fewer than 52 between 1933 and 1936, covering cathode ray tubes, DC restoration, AGC circuits, power supplies, antennas and cables and various electronic circuits.

This very condensed version of the story of EMI and HD television is covered in the two biographies. Russell Burns wrote another book in the IEE History of Technology series: *Volume 7 British television — the formative years is particularly relevant.*

Electronics

Although initially he was trained in heavy electrical engineering, Blumlein developed considerable ability in circuit design. This was gained from his work on telephone engineering, where most of the knowledge of circuit designs already existed although in those days electronics was not a separate science. His contribution to the design of electronic circuits during the television research period was considerable.

Negative feedback many of his circuits used negative feedback, both current and voltage, to linearise amplifiers and reduce the effects of variation in valve characteristics.

Cathode follower he appears to be the first person to appreciate the properties of the cathode follower circuit which he employed extensively in the equipment of the London Television Station.

Long-tailed pair Blumlein's long-tailed pair circuit was devised originally for the eight-mile video cable network which linked various Emitron camera sites in central London to the television transmitter at Alexandra Palace used during transmission of the coronation procession. The problem was to amplify the signals applied in push-pull while rejecting common mode push-push interference. In telephone practice a transformer was used, but in 1936 transformers able to handle the video bandwidth were not available, hence the long-tailed pair circuit. Blumlein gave the circuit its unusual name and it was so descriptive that it stuck.

In post-war years the circuit has been used in DC amplifiers (I used it when developing a DC amplifier in my first two years with the then Road Research Laboratory in 1947 but did not then realise it was a Blumlein invention), in operational amplifiers, mixers in communications equipment, high-speed non-saturating switches and push-pull output stages for driving the deflection plates of cathode-ray tubes.

Combinations of two long-tailed pairs were used by the National Physical Laboratory in its first generation Automatic Computing Engine (ACE). It has been suggested that this might have come about because two or three of the NPL team designing ACE had worked with Blumlein.

Ultra linear amplification in 1937 Blumlein patented a circuit design, known as the ultra linear amplifier, which enabled the output impedance of a valve to be more nearly matched to its optimum load impedance. For many years, the ultra linear output stage in its push-pull form was used in post-war high fidelity amplifiers.

Blumlein(Miller) integrator Blumlein used the Miller effect, analysed by J M Miller of the US Bureau of Standards in 1919, in voltage integration circuits. These were used extensively during the Second World War as time bases and ranging circuits in radar equipment. Blumlein's patent application for this work was submitted on 5 June 1942, two days before his tragic death.

Other electronic developments by Blumlein included constant impedance networks, oscillator stabilisation and delay-line circuits.

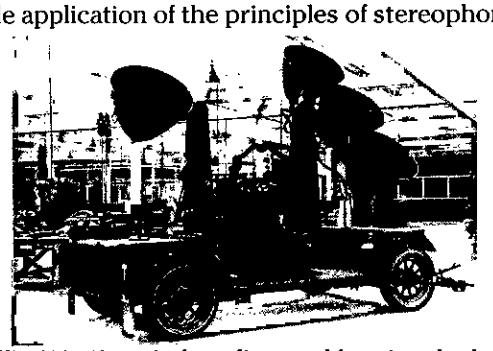
Blumlein and radar

The full story of the development of radar is beyond the scope of this article, but it is worth highlighting the work of Alan Blumlein in this field. His contribution would turn out to be vital, not only in the air battles over Britain and the air offensive on Germany, but also in the Battle of the Atlantic against the U-boats.

EMI's official involvement in the government's radar programme dated from 1940, when the Hayes-based company was asked to solve an important minimum range problem associated with air interception radar (see below). Before 1940 EMI had devised, as a private venture, a radar system which would enable the range, bearing and elevation of an aircraft to be determined. The method and equipment design of the '60 MHz job' as it became known were almost entirely Alan Blumlein's work.

This followed on from another EMI private venture project on sound location which had attracted the attention of the War Office's Royal Engineers Signals Board. The Board and the Air Defence Experimental Establishment (ADEE) were interested in the detection of aircraft by means of sound location. This had been a subject of interest since the end of the First World War when several static and mobile sound detectors had been investigated, and in 1938 EMI and the Gramophone Company were given a contract for the manufacture of the Mark VIII sound locator.

This contract stimulated Blumlein to consider the possible application of the principles of stereophony to

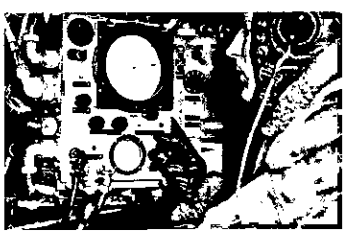


EMI's (1939) anti-aircraft sound locator designed to incorporate Blumlein's visual indicator equipment *Source EMI Archives*

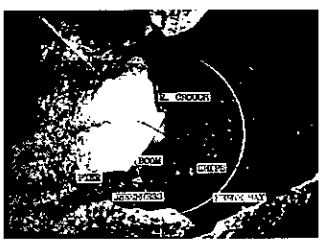
aircraft location. By October 1938 the company was able to demonstrate to the War Office a type of sound locator that included electrical listening and visual means of indicating the binaural effect. Blumlein's apparatus was known as VIE (Visual Indicating Equipment), and used two cathode ray oscilloscopes for the display of bearing and elevation information. The VIE filled a technological gap until adequate gunlaying radars were manufactured, by which time several thousand sound locators had been fitted with VIE. During the 1940 Blitz on London, Blumlein reportedly visited anti-aircraft batteries in Gunnersbury Park on his way home at night, just to see how they were getting on with his VIE and to offer advice. However, the fundamental limitation of acoustic systems was the relatively slow speed of sound and the effect of atmospheric conditions on the accuracy. Blumlein was fully aware of these limitations and the '60 MHz job' was developed to replace the use of sound waves by electromagnetic waves.

Minimum range problem

The Air Ministry Research Establishment (AMRE) had developed an Air Interception (AI) Mark III radar for night time use. Trials had shown that the minimum range of the radar, 1000 to 1500 feet, was too great to allow night fighters to press home an attack; the maximum effective range of the Browning 0.303 guns carried on most night fighters at



The EMI type 184 AH2S fitted into an aircraft *Source: EMI Archives*



An H2S c.r.t image of the Wash

A Wellington of Coastal Command fitted with a nose-mounted ASV Mark *111* scanner *Source: DERA Malvern*

the time was 600ft. The solution of the minimum range problem was of such crucial importance that from April 1940 three organisations considered the problem, AMRE, RAE Farnborough and EMI.

Blumlein and his colleague White quickly solved it. The story goes that Blumlein and White visited AMRE in Dundee and on 23 April returned to Hayes with part of the AI system. Due to the highly secret nature of the equipment it travelled with them in the first class sleeping compartment rather than in the goods van. Blumlein, White and another colleague Harker, worked rapidly and by 27 May had produced a new version which included 'a high voltage anode modulation scheme'. This was tested in a Blenheim IV night fighter on 14 June 1940. The maximum and minimum ranges were 19000ft and 450ft respectively, so the minimum range problem had been solved.

However, it required a combination of AI and GCI (ground control interception) to be perfected before really effective results could be achieved. This was so by March 1941, when 27 German aircraft were destroyed. In April the losses

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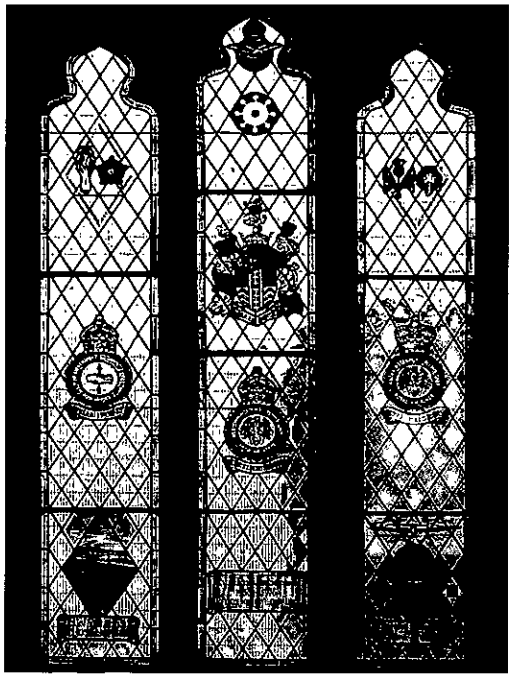
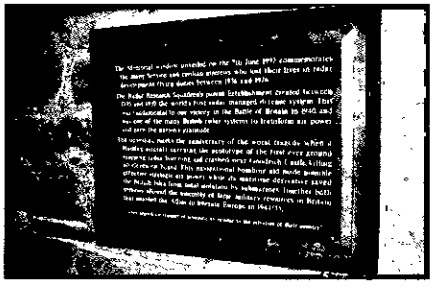
increased to 53, and in May 111. These were losses the Luftwaffe was reluctant to sustain, and by the end of May 1941 there was no large-scale aerial bombardment of the UK, comparable with the Blitz, until the V1 and V2 weapons appeared in 1944. Had the equipment been available in 1940 thousands of civilian lives would have been saved. There is much more to tell about Blumlein's research on radar, but no account would be complete without a brief summary of his contribution to centimetric radar, that is radar using wavelengths of 3cm to 10cm (frequency between 8 and 12 GHz, or the 'X-band'). Indeed it was while testing one of these devices that he lost his life.

Centimetric radar

Radar based on high frequency, using first the klystron and then the cavity magnetron transmitters, became an essential target of research. It was required for more effective night interception and later as target location for bombers, both in raids over Germany and for the location and destruction of U-boats in the Atlantic. Blumlein's circuit and component designs were critically important in the development of these devices. His solution to the problem of modulating the cavity magnetron which led to the use of a hard valve modulator, using two artificial delay lines, was employed in several types of centimetric radar.





Thanks to English Heritage and a great deal of fund raising, a stained glass window was placed in the chapel of Goodrich Castle near the crash site on 7 June 1992 as a memorial to the Radar Research Squadron and to commemorate the fiftieth anniversary of the crash of the Halifax bomber. The photographs show the window and below it, the memorial plaque.
(Photos above and front cover by John Tyler FIOA)

H2S and ASV

H2S was the code name given to the proposed blind bombing device which was to use the AI (aircraft interception) radar type of equipment. ASV (Air Surface Vessel) radar Mark III was intended for the battle against U-boats. The earliest operational systems of both the RAF H2S and the Coastal Command ASV Mark III were developed and engineered, apart from the scanner and antenna, by an EMI group led by Alan Blumlein. EMI's Gramophone Company manufactured the systems. Blumlein's team were able, after his death, to continue with the further development and manufacture of the system with the Telecommunications Research Establishment (TRE). There was concern that if the magnetron were used in raids over Germany and an aircraft was shot down the Germans would learn the existence of the magnetron and develop their own systems. This worry was a real one, since the magnetron was so robust in construction that it could not be destroyed by the usual explosive charges used in aircraft when equipment had to be destroyed. This resulted in a delay in the use of H2S over Germany until 1943 when it proved its worth.

H2S/ASV radar was one of the very great wartime technological developments. Both the bombing offensive over enemy territory and the battle against the U-boats were enormously aided by its use. Blumlein's role in the programme was supreme. It was his genius and the talents of his group which enabled the very crude images produced by early versions of AI radar to be replaced by excellent, meaningful, images capable of being interpreted by the average RAF/Coastal Command navigator or bomb aimer.

As Watson-Watt said in his book, *Three Steps to Victory*: 'the brilliant Blumlein was key man in an always-small H2S team'.

The crash and its aftermath

It was when a magnetron-based version of H2S was being tested by TRE and the EMI team in the Halifax bomber on 7 June 1942 that the tragic accident occurred which cost the lives of eleven people including Alan Blumlein.

The TRE personnel were Squadron Leader R J Sanson, Pilot Officer C E Vincent and Geoffrey Hensby. In addition to Alan Blumlein, the EMI staff included Cecil Browne and Frank Blythen. The other victims were RAF crew members.

The cause of the crash was a fire in the starboard outer Merlin engine which could not be extinguished. This led to failure of the wing spar, and the aircraft turned over onto its back over the River Wye and dived into the ground. The fire destroyed most of the aircraft but the magnetron transmitter survived intact.

The fundamental cause of the accident was eventually discovered to be a maintenance fault with the starboard outer engine. One inlet valve tappet nut out of 192 in all four engines had not been sufficiently tightened during a recent engine service. The nut unscrewed and the tappet broke, allowing fuel to ignite in the induction manifold and to set fire to the wing fuel tank. Human error resulted in eleven deaths including that of arguably the greatest British electronics engineer of the twentieth century. He was just 38 years old. His colleagues Blythen and Browne were excellent engineers too: they were only 30 and 37 respectively.

Postscript: The magnetron helped Britain win the war. At the heart of every microwave oven lies a magnetron, but how many know that?

Heathrow night flights to continue

Residents living under the Heathrow flight path have failed to get a ruling upheld which could have led to a ban on night flights. The European Court of Human Rights ruled in 2001 that flights between 2330h and 0600h BST violated the human rights of eight people living around the west London airport by disturbing their sleep, but the government has won an appeal against that ruling. Its reasoning was that an end to night flights would have a major impact on British airlines and give rival European companies an unfair advantage. It was estimated that the extra cost to British Airways alone of switching flight times could have been as much as £320m.

The anti-aircraft noise group HACAN ClearSkies brought the case to the European court, and was encouraged by what it interpreted as a ruling that the group should be allowed to pursue the case in the UK courts. Chairman John Stewart claimed that the government wanted to extend the present night-time flying regulations for London airports until 2005, and pledged that his organisation would use the extra year to try to make their case in the UK courts.

However, the government said it was vindicated in its decision to lodge the appeal. Aviation Minister Tony McNulty said that the judgement cleared the way for a thorough review of policy on night flights at Heathrow, Gatwick and Stansted. The consultation announced earlier this year would take place during 2004.

The Human Rights Convention guarantees a person's right to 'respect for private and family life and home' and 'peaceful enjoyment' of their home.

More aircraft traffic

Lawyers for the Heathrow residents had argued successfully last year that the government's 1993 decision to ease restrictions on night flights breached that guarantee. The ruling was not legally binding but could have led to a ban on night flights at Heathrow and other airports in the UK and Europe.

HACAN said that although individual aircraft had become quieter, any benefit to residents had been offset by the increase in the air traffic volumes. It said noise problems caused by Heathrow were no longer confined to the south west of London, and that more than half a million people were now affected by Heathrow's night flights. Sixteen flights a night arrive and depart from Heathrow, with the numbers varying when there are delays. Night flights are defined as those landing and taking off between 2330h and 0600h. A small number of flights occur after 2330h, and some from 0400h, but most land and take off between 0500h and 0600h.

Airport expansion

Hounslow Council, which had helped the campaigners with legal costs, promised to carry on trying to get night flights banned. The council's environment spokesman, Cllr Ruth Cadbury, said that residents' quality of life would only get worse if Heathrow were expanded. There was still enormous pressure on the government to ban night flights at Heathrow, and she added that support was growing in the light of the recent proposals for airport expansion.

£20m Lottery grant towards RFH

Arts Council England has confirmed a £20 million National Lottery award towards the restoration, refurbishment and modernisation of the Royal Festival Hall. Work on the £57 million project begins in summer 2005. Welcoming the decision, Lord Hollick, Chairman of the South Bank Centre said: "We are delighted that Arts Council England has now re-affirmed its support for the restoration. The Royal Festival Hall and its programme of excellence in classical and contemporary music, dance and literature have been an inspiration for major cultural centres across the world. The rejuvenation of this historical building will transform the quality of the experience for artists, audiences and visitors. It will help us to build our ground-breaking education programmes and to extend the range of our work to attract wider audiences."

While the Arts Council England money will support the provision of a new, expanded education centre as well as public facilities in the foyers, it will mainly be directed towards the auditorium. The natural acoustic will be enhanced to meet classical music requirements - the core of the RFH programme. At the same time it will retain existing beneficial characteristics for amplified sound. The organ, which will be 50 years old next year, will be removed for restoration. Improvements to the platform and production areas will increase the hall's capabilities and efficiency.

The Royal Festival Hall project has already received confirmation of a £15m award, with a further £4.16m under consideration, from the Heritage Lottery Fund, specifically directed towards conservation, restoration and repair work to the fabric of the building. SBC's own fund-raising campaign is underway and has so far raised £4.5 million towards the project.

Job interviews - WISE advice for candidates

The WISE (Women Into Science and Engineering) Campaign has issued its free *Managing Your Interview* booklet, which aims to guide women scientists and engineers through the sometimes difficult interview process. Aimed primarily, but not exclusively, at women, its contents include guidance, sample questions, quotes and to-do lists to help people analyse their own value, and then work out how to convey that value effectively to potential employers. As Baroness Platt of Writtle, Patron of WISE, advises in her foreword: 'Don't only think about whether you are right for the job. Think also about whether the job and the company are right for you!'.

For more information contact: Nicola Kelly, WISE Media, email: nckelly@semta.org.uk tel: 020 72278420.

PEOPLE NEWS

New partner for SBA

Richard Muir has become a partner of Sandy Brown Associates. He rejoined the partnership as an associate last year after managing Sound Research Laboratories' London office for eight years. He has an MSc in Environmental Acoustics and a BSc in Mechanical Engineering, combined with 16 years experience in building and environmental acoustics.

Richard further strengthens the practice's capabilities and enables the firm to manage expanding workloads at home and overseas. Among the major projects he is currently advising on are: Sheikh Isa Bin Salman Conference Centre, Bahrain; John Mark Hotel, Clerkenwell; Southside Arndale Centre redevelopment, Wandsworth; 10 Exchange Square, Broadgate; National Assembly Building, Bahrain; Dubai Conference Centre; and Herbert Gallery, Coventry.

Richard has taken a lead role on many key SBA projects, primarily in the fields of architectural acoustics and building services noise and vibration control, including advice on vibration isolation of sensitive structures. He also continues to apply his skills in projects involving environmental and construction noise and vibration.

Further information can be found at: www.sandybrown.com

4 June

Environmental protection

Mr Wray: To ask the Secretary of State for Environment, Food and Rural Affairs what measures are in place to make large industrial companies responsible for their immediate environmental surroundings; and what plans she has to strengthen regulations.

Mr Meacher: Many industrial activities in Great Britain are currently regulated under Part I of the Environmental Protection Act 1990. This introduced the systems of Integrated Pollution Control, which controlled releases to all environmental media, and Local Air Pollution Control, which controlled releases to air only.

The Pollution Prevention and Control (England and Wales) Regulations 2000 were made under the Pollution Prevention and Control Act 1999 and will eventually replace Part I of the Environmental Protection Act 1990. The Regulations implement the European Community (EC) Directive 96/61/EC on Integrated Pollution Prevention and Control (IPPC) in so far as it relates to installations in England and Wales.

The IPPC regime applies an integrated environmental approach to the regulation of certain industrial activities. This means that emissions to air, water (including discharges to sewer) and land, plus a range of other environmental effects, must be considered together. It also means that regulators must set permit conditions so as to achieve a high level of protection for the environment as a whole.

These conditions are based on the use of the 'Best Available Techniques' (BAT), which balances the costs to the operator against the benefits to the environment. IPPC aims to prevent emissions and waste production and where that is not practicable, reduce them to acceptable levels. IPPC also takes the integrated approach beyond the initial task of permitting, through to the restoration of sites when industrial activities cease.

Separate systems have been introduced to apply the IPPC Directive to Scotland, Northern Ireland and the offshore oil and gas industries. Regulation of industrial pollution in Scotland and Northern Ireland is a matter for the appropriate Ministers in these devolved administrations.

20 June

Deafness

Mr Wray: To ask the Secretary of State for Health what investment he has put into *(a)* researching deafness and *(b)* treatments to restore hearing since 1997.

Dr Ladyman: The estimated expenditure on hearing research through the Medical Research Council for the last five years is shown in the table.

Year	Expenditure £ million
1997–98	3.23
1998–99	3.49
1999–2000	3.34
2000–01	4.96
2001–02	3.94

Extracts are provided by Rupert Taylor FIOA

In addition, since 1997, projects relating to hearing impairment totalling £1.87 million have been commissioned through the health technology assessment programme and the national research and development programme for people with physical and complex disabilities. Under the Department of Health's Policy Research Programme, a number of universal neonatal hearing screening pilots are in progress, with funding of £94,000.

25 June

Live music

Bob Spink: To ask the Secretary of State for Culture, Media and Sport what measures she is taking to increase the opportunities to hear live music in the UK in *(a)* pubs, *(b)* public halls and *(c)* public open spaces.

Mr Caborn: The Licensing Bill will provide a unified system for the regulation of licensable activities, removing the need for the current system of separate annually renewable, public entertainment licences. Under the Bill a pub, qualifying club, community hall or indeed any other premises applying for authorisation under a premises licence for the sale and supply of alcohol will be able to apply, at the same time, for authorisation under that licence for the provision of regulated entertainment, such as live music, without incurring an additional fee. Once granted, a premises licence will have effect until the licence is revoked or surrendered, but otherwise will not be time limited unless the applicant so requests. We believe that this unified system will open up more opportunities for live musical events.

Also the government has made plain its intention to exempt church halls, village halls and other community buildings from the fees associated with the provision of regulated entertainment, including live music. However, a fee will be payable if the applicant also seeks authorisation for the sale or supply of alcohol. We believe that these exemptions from the fees associated with the provision of regulated entertainment will also broaden the opportunities for live musical events.

The Bill provides that a premises can be any place and live music or other regulated entertainment on public open spaces would be licensable, subject to satisfying the conditions in Schedule 1 to the Bill and any exemptions being relevant. We will, however, be encouraging local authorities to obtain premises licences authorising the provision of regulated entertainment for public open spaces, such as village greens, on which many performances take place. No additional licence would then need to be obtained by anyone wishing to provide regulated entertainment on premises covered by such a licence, although the consent of the local authority holding the licence would be required.

All short-term small scale events, whether in a pub, public hall or public open space could also benefit from the more informal system of permitted temporary activities under the Bill, which would require a simple notification to the licensing authority and the police and a small fee of around £20. The Bill has been amended to increase the number of temporary event notices that can be given in respect of the same premises from five to 12, subject to a maximum number of 15 days for that premises during which permitted temporary activities may take place in a calendar year. The Bill has also been amended during its passage to increase the period permissible for any temporary event from 72 hours to 96 hours.

2 July 2003

Aircraft noise

Mr Colman: To ask the Secretary of State for Transport what breaches of night flight noise limits under the quota count system there have been on the Heathrow flight paths since the current night flights restrictions began.

Mr McNulty: None. I wrote to my hon Friend about this on 20 June 2003 and I have now placed a copy of that letter in the Libraries of the House.

Mr Colman: To ask the Secretary of State for Transport what discussions his Department has had with international experts on International Civil Aviation Organisation noise certification; and what reasons these experts have given for the difference between locally monitored night flight noise levels and certificated noise levels in the Heathrow area.

Mr McNulty: Certification testing is carried out under strictly controlled meteorological and acoustical conditions and using defined flight path procedures. It follows that when local conditions differ so too will the noise. The extent to which currently certificated noise levels correlate with operational noise levels is one of the items being examined by a Working Group of the Committee on Aviation Environmental Protection (CAEP) of the International Civil Aviation Organisation.

The Working Group will take account of data for a large range of aircraft types that operate at night at Heathrow, Gatwick and Stansted (recently published in *Quota Count Validation Study: Noise Measurements and Analysis*, ERCD Report 0205), as well as data from some airports in the USA and France. The UK is represented on the CAEP Steering Group and the relevant Working Group by officials from the Department for Transport and the Civil Aviation Authority respectively.

7 July

Aircraft Noise

Dr Cable: To ask the Secretary of State for Transport what plans he has to change the measurement criteria for aircraft noise in the UK to correspond to those of the World Health Organisation.

Mr McNulty: WHO noise guideline figures are given in terms of equivalent continuous sound level (dBA L_{eq}) and of the sound event peak (dBA L_{max}). L_{eq} is already the established metric for averaging aircraft noise, as recommended in the planning guidance note PPG 24. L_{max} and SEL (which takes account of event duration as well as peak level) are also extensively used in describing individual noise events.

In due course, noise contours will also be produced for aircraft noise and for other sources in accordance with the metrics, again based on L_{eq}, prescribed by EU Directive 2002/49/EC.

Dr Cable: To ask the Secretary of State for Transport what research he has *(a)* commissioned and *(b)* published in the last two years on the impact of different aircraft noise levels on those affected.
Mr McNulty: The Department for Transport commissioned a study into attitudes to noise from civil aircraft sources in England in November 2001; it is expected to report towards the end of next year.
This major study was commissioned following three earlier, smaller-scale studies commissioned by DETR into the effects of noise specifically at night: *Adverse Effects of Night-Time Aircraft Noise* (CAA R&D 9964); *Aircraft noise and sleep—1999 UK Trial Methodology Study* (Flindell *et al.*) and *Perceptions of Aircraft Noise, Sleep and Health* (Diamond *et al.*) all published during 2000.

8 July

Mobile phones

Tom Brake: To ask the Secretary of State for Transport what estimate the government has made of *(a)* how many people might be fined under the proposed offence of using a hand-held mobile phone while driving, *(b)* how many people would contest the fines and *(c)* the revenue to be raised through fines in the first year of operation.
Mr Jamieson: Enforcement is a matter for the police. However, the Department published a partial Regulatory Impact Assessment last year when it consulted on the proposal for a new offence of using a hand-held mobile phone while driving. Based on prosecutions for failure to wear a seat belt, the assessment suggested that perhaps up to 100,000 fixed penalty notices at £30 each might be issued a year. Fines could therefore total £3 million a year, depending on the level of enforcement.

10 July

Heathrow Airport

Mr Coleman: To ask the Secretary of State for Transport what estimate his Department has made of the number of residents in London who would be affected by increased noise levels if a third runway was constructed at Heathrow airport.
Mr McNulty: The *Future Development of Air Transport in the United Kingdom-South East* consultation document (Table 7.3) does not give estimates for London alone. In the consultation document it is estimated that in 2030 the population living within the 57dBA L_{eq} noise contour would be 332,000 if a third runway were constructed (which would include parts of Berkshire, London, South Bucks and Surrey), compared with 278,000 if no runway were built. The 332,000 figure includes people living in areas that would be affected by air traffic using the third runway who would experience increased noise levels compared with today, as well as people in other areas affected by traffic using the existing runways (also within the 57dBA L_{eq} noise contour) who would experience reduced noise levels. For comparison, the figure for the resident population living in the same noise contour in 2000 given in the consultation document was 307,000. This had fallen to 258,300 by 2002.
Mr Coleman: To ask the Secretary of State for Transport whether he expects new areas of Hammersmith and Fulham to be affected by the construction of a third runway at Heathrow airport.
Mr McNulty: The modelling of noise impacts that is reported in the consultation document *The Future Development of Air Transport in the United Kingdom-South East* suggests that noise generated by aircraft using the new runway would not exceed 57 dBA L_{eq} in the London Borough of Hammersmith and Fulham. However, the purpose of the assessment was to allow comparison of different options at a variety of locations; it does not purport to be a precise prediction of the noise effects at specific locations.

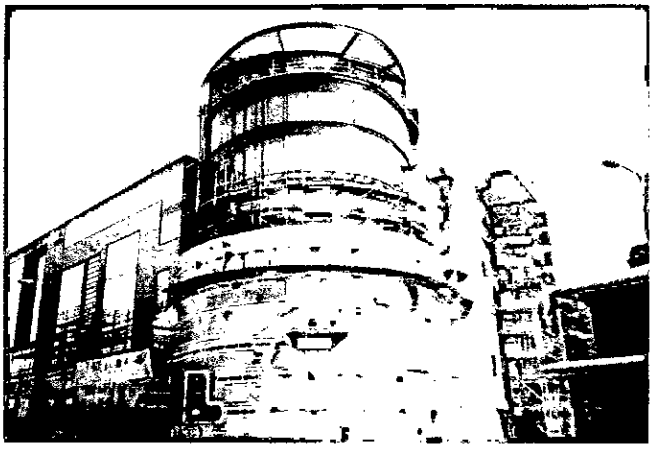
17 July

Night flights

Mr Bellingham: To ask the Secretary of State for Transport *(1)* what assessment has been made by the Department of the economic cost of removing the ban on night flights at Heathrow airport, in terms of the effect on property values on the flight path; what conclusions have been drawn; and if he will make a statement; and *(2)* what estimate the Department has made of the economic cost each year of continuing the ban on night flights at Heathrow imposed in 2001 in terms of its impact on the airline industry.
Mr McNulty: There is no ban on night flights at Heathrow but, since 1962, various restrictions have been imposed on night flying, in recognition of the disturbance to some people from aircraft noise at night. The restrictions are reviewed from time to time. Details of the present restrictions are given in the consultation paper *Night flying restrictions at Heathrow, Gatwick and Stansted,* which sets out our proposal to extend those restrictions until October 2005. The consultation closed on 11 July.

A Proctor Group

Vibration isolation for multiplex cinema



Edinburgh's new12-screen multiplex cinema

A new 12-screen multiplex cinema in Edinburgh utilises several **A Proctor Group** products. The project, which builds an old, listed clock face into the new building, required vibration isolation materials. Having looked at the specific frequencies generated through the cinema sound systems, along with the loadings, the company supplied *Sylomer* pads to prevent vibration travelling through seating areas. Sylomer is a technically advanced foam material with a unique cell structure designed to combat specific audible and subsonic frequencies. McKean, the main contractors, also installed *Styrofoam Floormate 350* as an efficient thermal insulator on the ground floor, and *Probuild 880* as the vapour control layer.

Recently, A Proctor Group has also brought together on a single web site all its technical literature from the acoustic insulation, vibration isolation, geo-engineering, thermal insulation, vapour control, timber frame, and pitched roofing divisions. Full technical details, drawings, specifications, case studies, FAQs and (where applicable) BBA certificates are all readily available. Areas of the site in Spanish, Portuguese, German, French and Japanese, reflect the company's volume of overseas business. Phase 2 of the site will be launched next year, promising more inter-activity and focus on specification and on-line learning.

Further details tel: 01250 872261
www.proctorgroup.com

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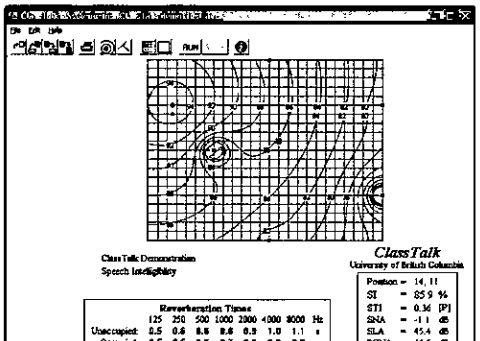
ClassTalk Simulating the classroom on computer

ClassTalk is a novel hardware and software system for modelling, predicting, visualising and, with the sound module, auralising speech in noise with reverberation during simulated computer walk-through. It is designed to be a simple, fast, accurate and user-friendly tool for evaluating the acoustical quality for speech, and sound-control measures, in typical classrooms, both objectively and subjectively.
Using ClassTalk, the physical and acoustical characteristics of a classroom and its noise sources can be defined. The system takes into account occupant sound absorption and student activity noise. The display shows a classroom floor-plan with the speech-source, noise-source and user-defined receiver position.
Five outputs - speech intelligibility, speech-transmission index, signal-to-noise level difference, speech level, and background-noise level - are calculated and displayed, and by moving the receiver icon, you can walk-through the virtual classroom. Reverberation times with the room unoccupied and occupied are also calculated.

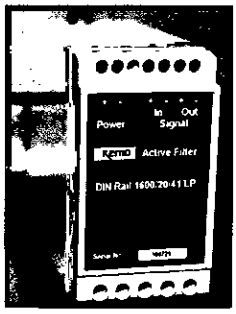


With its simple data input and output, its user-friendly graphical user interface and its comprehensive help file, the system puts reliable classroom acoustical prediction within the reach of the non-specialist. It is a simple and accurate speech-quality screening tool.
ClassTalk was developed by Murray Hodgson, Professor of Acoustics, The University of British Columbia, Canada.
A demonstration version is available by entering *ClassTalk* at: www.flintbox.ca

Kemo

Easing signal conditioning in industrial applications

The **Kemo** DR range of DIN rail mounting filters offers a fast, easy-to-install solution to signal conditioning in electrically noisy industrial environments. A combination of configurable input gain and a flexible range of signal filters makes the devices suited to applications such as noise reduction, anti-aliasing, band limiting and signal optimisation in industrial data-acquisition, measurement and control systems.
The new family is based on the established *CardMaster 1* filter carrier card. Two versions are available: the DR 1200, offering a fixed factory-set frequency from 1Hz to more than 500kHz, and the DR 1600, in which the frequency can be set in 255 steps by DIP switches, with versions covering the frequency range from 0.2Hz to 127.5kHz. A range of filter responses available includes low-pass, high-pass and notch filter characteristics.



Both versions have configurable input gain, set by externally accessible DIP switches, from 0 to +60 dB, AC/DC input coupling, single ended or differential inputs, and a 24V IEPE transducer power supply that is adjustable to 10mA. The signal zero voltage is floating with reference to the power supply, allowing flexibility in system earthing. The differential input allows use with 4 to 20 mA systems in conjunction with a current-sense resistor.
The DR unit measures 45 by 78 by 110 mm, and fits onto a 35 by 15 mm DIN rail. Screw terminal connectors are fitted.
Further details tel: +44(0) 20 8658 3838
fax: +44(0) 20 8658 4084
web: www.kemo.com

ICSV11
Advance notice

The Eleventh International Congress on Sound and Vibration (ICSV11) will take place from 5 to 8 July 2004 at St Petersburg, Russia. For further details contact Prof N I Ivanov, Congress Secretariat, Baltic State Technical University, PO Box 08A9, 1st Krasnoarmeyskaya Str 1, 190005, St Petersburg, Russia. Tel: +7(812)110-15-73 Fax: +7 (812) 316-15-59 e-mail: icsv11@rol.ru web: www.monomax.org/icsv11

Thurlby Thandar Instruments

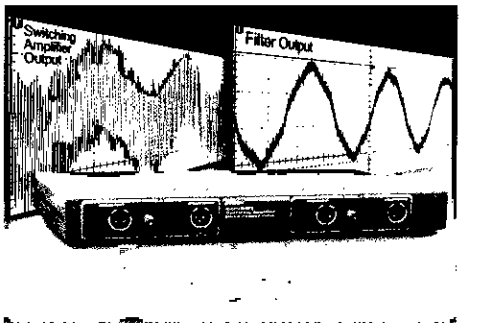
Hand-held 1.3 GHz high-resolution frequency counter

The *PFM 1300* from **Thurlby Thandar Instruments** (TTi) is a UK-built hand-held frequency counter which can measure signals from 5 Hz to 1300 MHz. Costing £99 (plus VAT), it comes in the same price category as hand-held multimeters.
Yet, despite its compact size and low cost, the unit incorporates many advanced features. In particular, it uses the reciprocal counting technique to achieve high measurement resolution at all frequencies. This results in a high-resolution measurement regardless

of the signal frequency. The frequency range is from 5Hz to 1300MHz with excellent sensitivity throughout (typically 15mV). A low-pass filter can be selected when required.
The counter is housed in a robust ABS case weighing less than 200g. There is a large LCD display of very high contrast incorporating 15 annunciators covering measurement function, measurement time, units, overflow, trigger activity and low battery.
Low power consumption circuitry ensures long battery life. A 'push to measure' facility provides an immediate reading on the press of a key followed by an automatic power-down after 15 seconds, maximising battery life when continuous signal monitoring is not required.

Switching amplifier measurement filter

The new *AUX-0025* switching amplifier measurement filter from Audio Precision is now available from TTi, the exclusive UK distributor. Manufacturers of power amplifiers are moving to switching designs to make their amplifiers lower in cost and more efficient than linear power amplifiers. This technology has particular appeal in automotive and personal stereo applications where efficiency, low battery consumption, small size and low cost are important.
The AUX-0025 is a dual-channel, multi-pole LRC passive filter which provides the necessary attenuation of out-of-band signals and reduces the steepness of the fast switching edges. The input connectors replicate the input connectors found on analyser inputs (XLR female and banana jacks). The output connectors are XLR male. Since loading capacitance is an issue, two short XLR male to XLR female colour-coded cables are included.
The frequency response of the filter is ±0.05dB from 10Hz to 20kHz, with a typical



insertion loss of 0.05dB. High frequency rejection is greater than 50dB from 250kHz to 20MHz. Distortion is less than 110dB harmonic, measured at 70V peak-to-peak at 1kHz, or less than 100 dB intermediate at 70V peak-to-peak with 18kHz and 20kHz dual test-tone signal (intermediate distortion components are at 2, 16 and 22 kHz).
The AUX-0025 costs £655.00 (plus VAT).
Further details tel: +44 (0) 1480 412451
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Institute Diary 2003

18 - 19 September
Research Symposium, Acoustic characteristics of surfaces: measurement, prediction and applications
University of Salford

23 September
Environmental Noise Group
Wilson - 40 years on
Commonwealth Conference Centre, London

25 September
Executive,
St Albans

30 September
Diploma Tutors and Examiners & Education,
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30 September
Environmental Noise Group
IPPC
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7 October
Measurement & Instrumentation Group
Its how loud .... Are you sure?
NPL

9 October
Medals & Awards & Council,
St Albans

14 October
Engineering Division,
St Albans

23 October
Publications,
St Albans

4 November
Research Co-ordination,
London

5 - 6 November
Building Acoustics Group Autumn Conference 2003, Sound-bite
The Oxford Hotel, Oxford

6 November
Membership,
St Albans

7 - 9 November
Electroacoustics Group Reproduced Sound 19
The Oxford Hotel, Oxford

18 November
CCENM Examiners & Committee,
St Albans

20 November
Executive
St Albans

25 November
Meetings,
St Albans

2 December
CCWPNA Examiners & Committee,
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9 December
CMOHAV Examiners & Committee,
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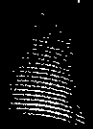

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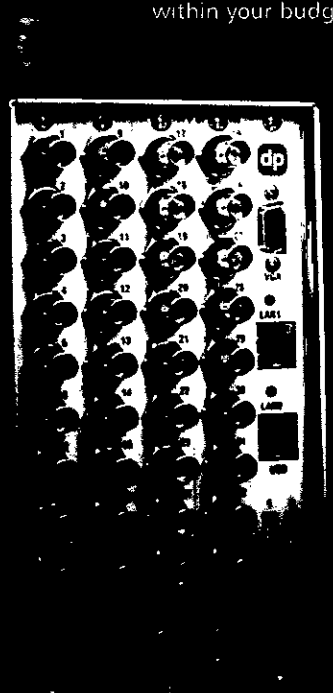

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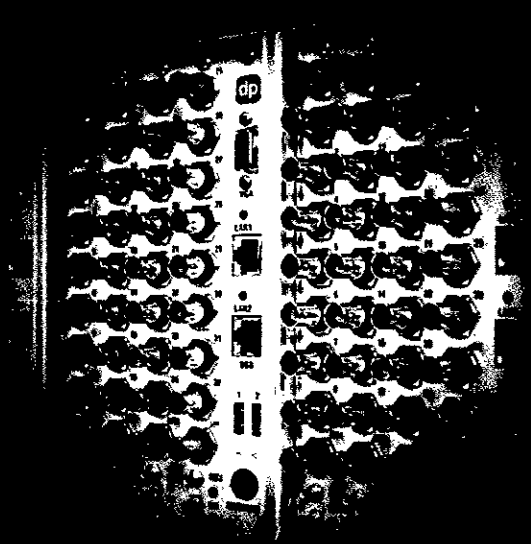

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